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SECONDARY EXPANSION IN REFRACTORY CLAYS*

By J. O. Everhart

Abstract

A large number of refractory clays show secondary or after-expansion with a marked increase in volume, usually occurring in the range from cones 6 to 14. Data presented in this paper were secured in an investigation made by the Ohio State University Engineering Experiment Station on twenty-one representative clays from Missouri, Ohio, Kentucky, and Pennsylvania. The findings indicate that the expansion is caused by opening up the natural lamination or bedding planes in the clay grains. Two methods for reducing or eliminating the expansion are given. Data concerning chemical analyses, petrographic examinations, and X-ray studies are presented.

I. Introduction

The data reported in this paper were secured in an investigation of the cause of the so-called secondary or after-expansion in refractory fireclay brick. The problem was suggested to the Engineering Experiment Station for study by a group of refractory manufacturers.

The property known to the industry both as secondary or after-expansion manifests itself as a considerable increase in volume in the temperature range of pyrometric cones 6 to 14. It evidently is confined rather definitely to the nonplastic types of clay. About one-half of the clays of this type occurring in the Appalachian field are subject to the expansion. Otherwise these clays are among the most desirable in the field.

Ware made from such clays will expand during the original firing if the temperature is in the range from cones 6 to 14. Beyond cone 14 they generally continue to shrink normally. When the firing temperature is below cone 6, the ware may expand in service if subjected to a temperature in its expansion range. For these reasons the problem is of considerable importance to the fireclay refractories industry. It should be noted here that a relatively small load is sufficient to eliminate expansion in the direction in which the load is applied. For this reason it sometimes happens that brick from the bottom of the kiln setting are smaller than those in the top.

The problem has been the subject of several technical papers. Different authors have advanced different theories as to the cause. They mainly seem to agree that a "bleb" structure is developed coincident with the expansion. Purdy[1] found an increase in true specific gravity accompanying the development of a bleb structure. Ogan[2] concluded that the permanent expansion was due to the formation of a bleb structure by volatilizing gases. Knote[3] stated that the difference in the behavior of plastic and flint clays is not due to difference in chemical composition but to physical structure. He gave no specific data regarding the structure. Powell[4] attributes marked expansion of a Kentucky clay at 2200° to the breaking down of iron compounds and the release

Table I

Geographical and Geological Occurrence of the Clays Used in This Investigation

Clay	Type*	Geographical occurrence (County and State)	Geological occurrence
A	Semiflint	Tuscarawas, Ohio	Lower Kittanning
B	Plastic	Lawrence, Ohio	Lawrence
C	Semiflint	Scioto, Ohio	Sciotoville
D	Flint	Cambria, Pa.	Upper Mercer
E	"	"	" "
F	Semiplastic	Carter, Ky.	Sciotoville
G	Flint	"	"
H	"	Tuscarawas, Ohio	Lower Kittanning
I	"	Scioto, Ohio	Sciotoville
J	Semiflint	Jackson, Ohio	Oak Hill
K	"	Carter, Ky.	Sciotoville
L	"	Clearfield, Pa.	Upper Mercer
M	Flint	Carter, Ky.	Sciotoville
N	"	Clearfield, Pa.	Upper Mercer
O	Semiflint	Tuscarawas, Ohio	Lower Kittanning
P	Plastic	Vinton, Ohio	Clarion
R	Intermediate	Calloway, Mo.	Lower Cherokee
S	Flint	Montgomery, Mo.	" "
T	"	Carter, Ky.	Sciotoville
U	Semiflint	Clearfield, Pa.	Upper Mercer
V	Flint	Carter, Ky.	Sciotoville

* Note: The term "flint" is used to describe those clays having a typical conchoidal fracture. The term "semiflint" is used to describe those clays hard in nature, lacking in plasticity, but not having the conchoidal fracture of flint.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division).

[1] R. C. Purdy, "Pyrophysical Behavior of Flint Fire Clays," *Trans. Amer. Ceram. Soc.*, **9**, 204–27 (1907).

[2] J. M. Ogan, "Cause of Permanent Expansion in Firebrick," *ibid.*, **13**, 602–11 (1911).

[3] J. M. Knote, "Chemical and Physical Changes in Clays Due to the Influence of Heat," *ibid.*, **12**, 226–64 (1910).

[4] E. B. Powell, "Boiler Furnace Refractories," *Trans. Amer. Soc. Mech. Eng.*, **1926**, 839–948; *Ceram. Abs.*, 5 [10] 335 (1926).

of oxygen and other gases. He attributes expansion in a Pennsylvania clay to entrapped gases in closed pores. Norton[5] suggested softening of fluxes and evolution of SO_2 and H_2S as the cause of expansion in a Pennsylvania brick. Booze, in a discussion of Norton's paper, states that secondary expansion is exhibited by a few flint clays in a limited section of Pennsylvania. His observation is not substantiated by this and other investigations. Kramm[6] states that above cone 1 the evolution of SO_3 gas is rapid and suddenly increases porosity.

TABLE II
RELATIVE EXTENT OF SECONDARY EXPANSION

No expansion	B, F, G, I, M, N, P, R, S, T, V
Slight expansion	A, C, E, H, J, K
Marked expansion	D, L, O, U

Probably the most thorough work on secondary expansion was an unpublished thesis by Phillips.[7] Among his numerous observations he notes that expansion is accentuated by reducing atmospheres, rapid firing, and coarse grinding. He observed the development of an open structure in the grains, which he believed was generated by gaseous pressure.

From conversations with a number of persons interested in refractories, a general opinion was indicated that sulfur gases were an important factor, if not the direct cause of the expansion.

II. Method of Investigation

Twenty-one clays were selected for study in the investigation; ten were true flints, eight were semiflints, and three were plastics. They were secured from the Pennsylvania, Ohio, Kentucky, and Missouri fields, and all are being used in regular production.

Each clay was subjected to a chemical and petrographic analysis. Firing behavior studies were made of each clay from cones 03 to 14.

NOTE: Chemical and petrographic analyses were made from small samples prepared by fractionation from a general sample of five hundred pounds. The chemical analyses were made by Downs Schaff; the petrographic examinations by the author, using both the fine-powder and thin-section methods; X-ray diffraction patterns were made of three of the clays in the laboratories of the Department of Mineralogy at the Ohio State University and at the General Electric Company at Schenectady.

TABLE III
CHEMICAL ANALYSES

Clay	SiO_2	Al_2O_3	Fe_2O_3	FeO	FeS	MgO	CaO	Na_2O	K_2O	H_2O^-	H_2O	CO_2	TiO_2	P_2O_5	SO_3	MnO	ZrO_2	Org. C	Org. H
A	59.74	25.52	0.78	0.34	0.86	0.14	0.50	0.05	0.19	1.17	9.25	0.08	1.40	0.20	0.02	0.01	0.01	0.06	
B	58.10	23.11	1.73	0.68	0.55	1.01	0.79	0.34	1.90	2.27	7.95	0.05	1.40	0.17	0.03	0.01	0.01	0.22	0.03
C	43.31	36.01	1.31	1.07	0.63	0.65	0.83	0.47	0.70	1.70	11.06	0.11	2.21	0.12	0.01	0.02	0.01	0.02	
D	44.43	37.10	0.46	0.55	0.22	0.19	0.60	0.10	0.55	0.80	12.95	0.11	1.84	0.21	0.01	0.01	0.01	0.10	
E	47.03	33.50	1.22	0.80	0.02	0.53	0.68	0.28	1.44	0.95	11.92	0.04	1.55	0.22	0.01	0.01	0.01	0.09	
F	48.02	31.07	1.21	0.97	0.20	0.55	1.07	0.38	1.01	1.55	11.01	0.05	2.33	0.02	0.01	0.01	0.01	0.74	0.11
G	44.78	35.11	1.18	0.74	0.14	0.55	0.77	0.29	0.44	0.84	13.07	0.07	2.22	0.02	0.01	0.02	0.01	0.11	
H	47.52	32.90	1.49	0.55	1.14	0.33	0.90	0.09	0.11	1.81	11.68	0.03	1.55	0.11	0.05	0.02	0.01	0.08	
I	42.90	36.81	0.92	0.77	0.14	0.68	0.92	0.33	0.59	1.40	12.83	0.12	1.65	0.12	0.01	0.02	0.01	0.10	
J	50.32	31.53	1.02	0.35	0.12	0.18	0.80	0.07	0.05	2.47	11.25	0.14	1.45	0.48	0.01	0.02	0.01	0.07	
K	44.24	34.89	1.50	0.88	0.05	0.54	0.75	0.14	0.61	1.70	12.21	0.33	2.20	0.17	0.01	0.03	0.01	0.01	
L	43.04	36.49	1.37	0.83	0.24	0.54	0.74	0.46	1.10	0.82	12.44	0.05	1.79	0.10	0.01	0.01	0.01	0.22	0.03
M	43.70	37.68	0.78	0.33	0.01	0.20	0.65	0.07	0.14	0.70	13.24	0.14	2.54	0.02	0.01	0.02	0.01	0.01	
N	44.02	38.03	1.04	0.42	0.03	0.22	0.70	0.14	0.29	0.65	13.37	0.14	1.15	0.12	0.01	0.01	0.01	0.02	
O	48.60	32.28	1.05	0.55	1.70	0.07	0.68	0.02	0.25	1.61	11.41	0.14	1.47	0.21	0.02	0.03	0.01	0.10	
P	46.72	33.06	0.68	0.55	0.34	0.19	0.61	0.42	1.53	2.21	11.50	0.02	2.20	0.12	0.01	0.01	0.01	0.04	
R	44.24	36.70	0.74	0.20	0.01	0.18	0.59	0.56	0.48	1.55	12.80	0.09	1.84	0.18	0.01	0.01	0.01	0.03	
S	44.04	38.03	0.63	0.22	0.01	0.12	0.40	0.10	0.22	0.78	13.55	0.04	1.82	0.28	0.01	0.01	0.01	0.01	
T	45.28	35.07	0.36	1.24	0.07	0.35	0.66	0.45	0.80	0.93	12.08	0.50	2.22	0.12	0.01	0.03	0.01	0.05	
U	44.01	36.02	0.98	0.95	0.09	0.39	0.60	0.19	1.20	1.12	12.38	0.19	1.65	0.21	0.01	0.02	0.01	0.32	0.04
V	44.55	35.15	0.88	0.93	0.03	0.22	0.59	0.15	0.40	1.77	12.10	0.18	1.81	0.14	0.01	0.01	0.01	1.23	0.17

The chemical analyses are given in Table III. Examination of these analyses indicates one generalization. An average analysis of the nonplastic clays that do not exhibit expansion shows fewer impurities than an average analysis of the clays that show expansion. This is true as to the content of free silica, iron oxides, total fluxes, pyrite, organic carbon, etc.

III. Petrographic Data

Data secured from petrographic examinations indicated the presence of a kaolin mineral in some

[5] F. H. Norton, "Thermal Expansion of Refractories," *Jour. Amer. Ceram. Soc.*, **8** [12] 799–815 (1925).
[6] H. E. Kramm, "Some Effects of Gypsum on Clay," *Trans. Amer. Ceram. Soc.*, **13**, 689–703 (1911).
[7] J. G. Phillips, Unpublished thesis for M.Sc. degree, Ohio State University (1924).

of the flint clays having properties which are not those of kaolinite. Ross and Kerr[8] have determined the existence of three distinct kaolin minerals, *viz.*, kaolinite, nacrite, and dickite. The mineral referred to is biaxial and optically positive. Kaolinite and nacrite are always optically negative, while dickite is positive. Further examination of the mineral as present in a Sciotoville clay gave the following data: (1) it is clear and transparent; (2) the grains upon which extinction angles could be measured classified themselves into two groups, the angle in one direction averaging 15.5° and in the other 22.9°; (3) the angle of extinction is between two and three degrees greater for red than blue light; and (4) the material is not stained by dyes. All of these properties are contrary to those of kaolinite, which is translucent, has an extinction angle of only 1° to 3.5° on the 010 face and none on the 001 face, does not react to red or blue light, and strongly absorbs dyes. On the other hand, dickite exists in clear transparent plates, is optically positive, has an extinction angle of 16° on the 010 face and 23° on the 001 face, has three degrees greater extinction in red than in blue light, and is unstained by dyes.

These data so strongly suggested that the fine aggregates in certain clays are kaolinite and the larger crystalline fragments are dickite that X-ray diffraction patterns were obtained for dickite, kaolinite, a Sciotoville clay from Ohio, and an upper Mercer clay from Cambria County, Pennsylvania. These two clays contained the highest percentages of the mineral in question. The patterns seem to establish definitely the fact that both of these clays contain a mixture of dickite and kaolinite. Graphic representation of the patterns is shown in Fig. 1. Dehydration curves also indicate that the Sciotoville clay retains some of its water of hydration above the temperature at which kaolinite is completely dehydrated.

A sample of dickite obtained from Chihuahua, Mexico, showed some tendency to expand at about the same range as the clays tested, but since several of the clays showing pronounced expansion gave no evidence of containing dickite, there seems to be no reason for attributing the clay expansion to the mineral dickite.

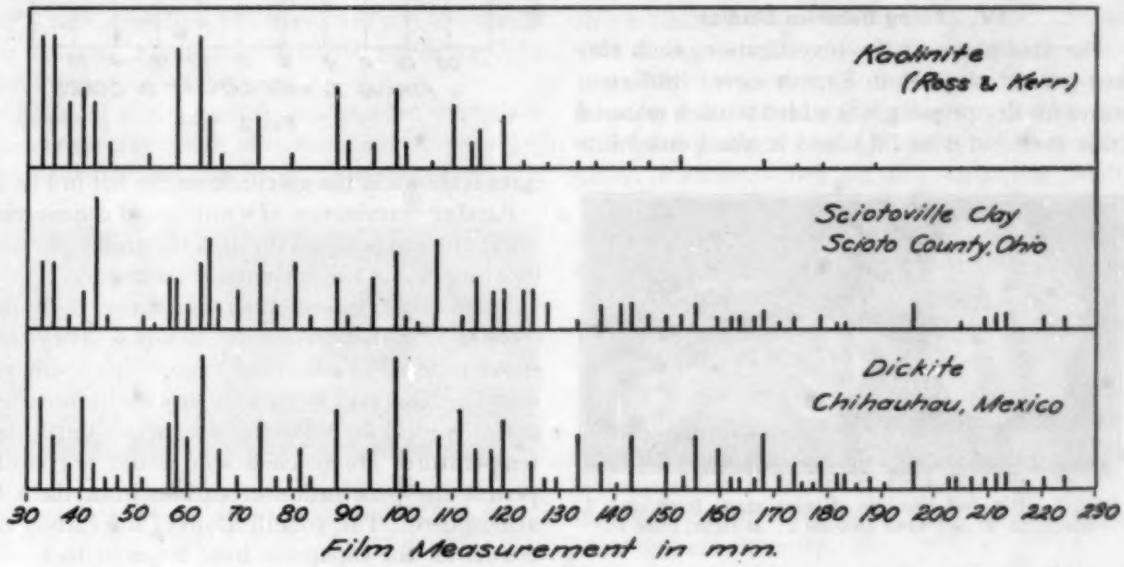
Kaolinite
(Ross & Kerr)
Sciotoville Clay
Scioto County, Ohio
Dickite
Chihauhau, Mexico
30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230
Film Measurement in mm.

FIG. 1.

The principal ingredient of all the clays examined is a kaolinite aggregate made up of small crystals ranging from colloidal size up to 75 microns in diameter. The true flint clays are likely to be more finely crystalline and much more homogeneous than semiflint and plastic clays. The kaolinite aggregates are firmly bonded together in flint clays, and the index of refraction of these aggregates indicates the presence of a bonding medium, which, if it is present, must have a chemical composition approaching the kaolinite ratio of

[8] C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165-E, pp. 151–80 (1930); see also *Jour. Amer. Ceram. Soc.*, **13** [3] 151–60 (1930).

alumina and silica. The semiflint and plastic types are not nearly so firmly bonded.

The flint clays of Pennsylvania and Ohio as a group are more coarsely crystalline than the Kentucky and Missouri clays of the same type.

The principal impurities and accessory minerals in the clays examined are quartz, limonite, pyrite, muscovite, and sericite. The impurities occurring in lesser quantities are zircon, hornblende, siderite, rutile, and tourmaline.

As far as we have been able to determine, there is no indication that secondary expansion is related to the presence of any of these impurities in the mineral form.

IV. Firing Behavior Studies

For this phase of the investigation, each clay was ground to pass an 8-mesh sieve. Sufficient water for dry pressing was added to each material (this averaged 6 to 7%), and it was formed into

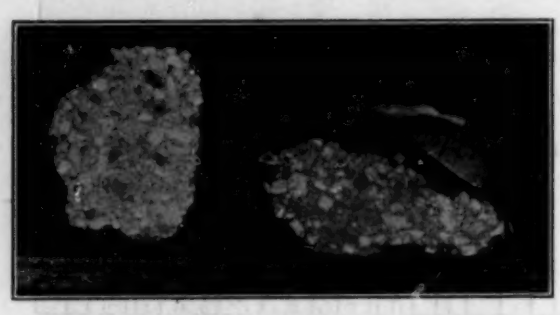

FIG. 2.—Polished sections of ware made from clay U. Specimen at left fired to cone 2; at right, cone 10.

briquets measuring $4^1/_2$ by $2^1/_4$ by 1 inch. Each clay was pressed without additions of other clay at 2000 pounds per square inch. Five test pieces from each of the twenty-one clays were fired at two-cone intervals from cones 03 to 14. Porosity and volume-change determinations were made on all twenty-one materials. Some showed expansion of the typical secondary or "after type," usually starting at cone 6 or soon after.

Another expansion, usually less in extent, frequently occurred at cones 01 or 2. This expansion seemed to be removed at about cone 4 and the body continued to shrink for a period of two or more cones, after which the larger and true secondary expansion occurred.

Sections cut from the specimens and polished on a lap show the development of a dark core in the center of the larger flint grains coincident with the low temperature expansion. The presence of such

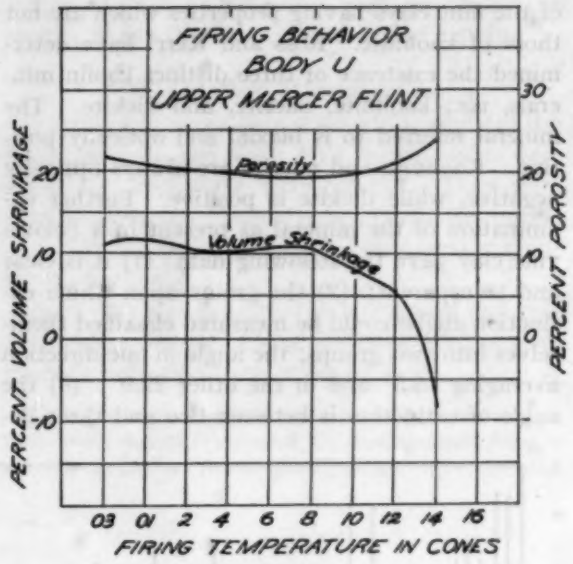

FIG. 3.

cores is shown in the specimen on the left in Fig. 2.

Further examination of a number of commercial brick, cut and polished through the grains, showed that such cores are a common occurrence.

Microscopic examination indicates that the cores are carbonaceous in nature. They are either residual or absorbed carbon (probably residual). The very dense structure of the flint-clay grains is ideal for retaining the carbon until high temperatures are reached and would not easily permit the penetration of carbon from the kiln atmosphere. The volatilization of the carbon accounts for the expansion from cones 01 to 4.

Since these carbon cores are not visible unless the grains in the structure are cut and polished through their interiors, casual inspection of frac-

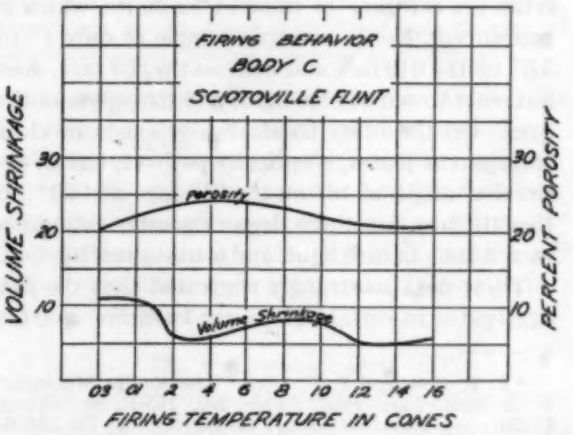

FIG. 4.

ture surfaces does not show their presence. Some early investigators may have considered this carbonaceous expansion to be an early phase of the later one occurring at a higher temperature.

At about cones 7 or 8 in this investigation and possibly one to two cones lower temperature in commercial firing, what is known as "the true secondary expansion" begins. The upper Mercer clay in Fig. 3 and the Sciotoville of Fig. 4 are examples. The upper Mercer clay is an example of an exaggerated case. In most cases the expansion is not quite so emphatic; it serves, however, to illustrate the action nicely. The clay has a rather constant volume from cones 03 to 8. Between cones 8 and 14, the volume changes from approximately 10% shrinkage to a 9% expansion; it is actually an increase in volume of 9% over the dry unfired condition.

Polished sections cut from expanded ware show the denser clay grains to be laminated. Several of these laminations may occur in the same grain and

FIG. 5.—Typical expansion of two semiflint clays in lump form, fired to cone 14; specimen at left, upper Mercer from Clearfield County, Pa.; right, Sciotoville from Scioto County, Ohio.

they are always oriented in the same general direction within the grain. They are usually barely perceptible when the expansion begins and become wider as the firing temperature increases. Their appearance and extent coincide with the beginning and extent of the expansion.

These laminations are not the typical bleb type arising from gas expansion in a vitreous structure. The refractory clays at these temperatures are not soft enough to show gas expansion.

Large lumps of the clays showing expansion open up in a characteristic manner as shown in Fig. 5. These fracture planes are always in a generally parallel direction. Sometimes they occur as frequently as thirty to the inch. The fact that the fracture planes follow a common direction even in the relatively small grains indicates that the failure is due to mechanical or physical causes. It appears likely that there are inherent structural weaknesses in the raw clay that are brought to the point of failure by certain stresses developed during firing.

There is considerable evidence that the refractory coal-measure clays of the Appalachian field are derived from deposits of micaceous silt and not from feldspathic material.[9] The mica flakes naturally settled into a stratified structure, and this, coupled with the inherent lamination in the mica, was productive of a structure still to be seen in some of the clays which have not been sufficiently altered to destroy it. Throughout geological time the acid swamp waters have leached out the major portion of the potash and part of the silica, accomplishing a conversion of kaolinite. In the case of the semiflint clays, the alteration has not proceeded far enough to destroy the evidence of lamellar sedimentation. Further purification and alteration produce a true flint clay without directional fracture. Beyond this stage an oölitic structure is developed, and this group of clays embodies a complete gradation from true flint to diaspore-type clays. Clays of the plastic type are also devoid of any repeated regularity of structure that produces a directional fracture.

In the experience of the writer, no true flint-type clay void of laminated structure nor any plastic clay has ever shown this expansion. This observation has not been previously made in the literature, but it is substantiated by the twenty-one clays in this investigation and thirteen others observed subsequently.

The theory of micaceous origin with subsequent purification by the leaching out of the impurities and by the conversion to kaolinitic composition is strengthened by the fact that the true flint clays, or more generally those clays that do not expand, show an analysis averaging lower in impurities and higher in alumina.

That the expansion is caused by opening along well-defined planes of discontinuity is apparent. The factors causing the opening are not so well defined. They may be purely mechanical, thermochemical, or a combination of the two. Assuming that a temperature gradient exists between the outside and the center of the clay grains during firing, any grain will be under a constant stress because of differential shrinkage between outer surface and inner area. The difference in dimen-

[9] Personal conversation with Wilber Stout, State Geologist, Ohio Geological Survey.

sion will be small, but it is constantly present and would be relieved by failure along any plane of weakness, such as the lamination planes known to exist.

Petrographic examination indicates that the glass phase developed along the fracture planes at cone 14 has a higher index of refraction than the glass within the clay mass somewhat removed from these planes. This would indicate the presence of alkali or iron fluxes along the planes and is compatible with the theory of micaceous silt origin with the subsequent leaching out of the alkalis, irons, etc.

If the area along the striation planes is higher in fluxes, as the index of refraction indicates, the first glass development would be along these planes. At a higher temperature when the glass has formed in appreciable quantity throughout the general clay mass, the low melting glass along the planes will be quite fluid, whereas that away from the planes will be more viscous. In general, surface-tension effects in fluids are parallel to viscosity. The surface tension of the more viscous glass phase on either side of the planes of weakness would be considerably greater than that in the immediate vicinity, and shrinkage would be away from these planes. Being mechanically weak and in a rather fluid condition, they would tend to open under the stress. That the material adjacent to the planes is in a thermoplastic condition is shown by the lump of fired clay on the right in Fig. 5. The viscous fibers or threads developed as the two sides of the planes separated are easily seen.

Assuming the possibility of an initial separation along well-defined planes during firing, the condition may be further aggravated on cooling. The fact that additions of alkalis, iron, etc., to glass increases thermal expansion is well established.[10] Such being the case, glass along the planes already opened would shrink more in cooling and further distort the structure.

Aside from any consideration of glass development, the obvious discontinuity of structure and general lack of uniformity in clays of the type showing expansion would almost preclude satisfactory firing behavior. Some of the clays examined consisted of layer upon layer of kaolinite flakes; in fact, they were almost as foliated as the leaves of a book. These clays were very weak parallel to the foliation planes.

[10] S. English and W. E. S. Turner, "Relationship between Chemical Composition and the Thermal Expansion of Glasses," *Jour. Amer. Ceram. Soc.*, **10** [8] 551–60 (1927).

V. Methods of Reducing Expansion

It seems obvious that some measure of success should be obtained by grinding the clays to such a degree of fineness that none, or at least only a small proportion of the grains, will be of sufficient size to contain any of the original lamination planes in their structure.

The clay designated as "U" was selected for this test since it had a tendency to open up in the lump with a greater frequency than any of the others. A calcined lump of clay U is shown at the left of Fig. 5. The openings average about thirty to the inch in this clay. Specimens were prepared from it, ground to pass 4-, 8-, 14-, 20-, 28-, and 35-mesh screens. They were pressed at 2000 pounds per square inch and fired to cone 14. The results are given in Table IV and Fig. 6.

TABLE IV

Grain size	Volume shrinkage at cone 14
4	−8.65
8	−3.97
14	−0.15
20	1.10
28	3.61
35	7.30

The lengths of the specimens in Fig. 6 give some idea of the results obtained. The thickness of the specimens is not a criterion of their behavior, inasmuch as they were not all made with the same original thickness.

Figure 7 shows the structure of the body made from 4-mesh material after firing. The magnification is about 1.5 diameters. Expansion by opening along the parallel planes is clearly shown. The behavior of 8-mesh material is shown by the specimen at the right in Fig. 2.

VI. Forming Pressure

The effect of increased forming pressures was investigated. Typical results secured on body U are given in Table V. The material was ground

TABLE V

Forming pressure (lb./sq. in.)	Volume shrinkage from pressed size
2000	−2.85
4000	−2.35
6000	−1.30
10000	4.65

through an 8-mesh screen and was tempered with 6% moisture.

The effect may be due to two separate causes or both acting in conjunction. The high forming pressures conceivably fracture the larger grains, reducing the percentage of coarse material. Henry[11] has found that considerable crushing of nonplastics in abrasives occurs when high forming pressures are used. It is a well-known fact that moderate loads will stop the tendency to expand in the direction in which the load is applied. The added strength secured by higher forming pressures may be sufficient to produce the same effect as extraneous load.

If the manufacturer should resort to finer grinding, he is confronted with the problem of losing some of the desirable properties in the finished ware, which are obtainable by the present trend toward coarser grinding and grain sizing for maximum density. To grind all of the material through a 28- or 35-mesh screen would also increase preparation costs considerably.

FIG. 6.—Length of specimens illustrates the effect of grain size on the tendency to expand.

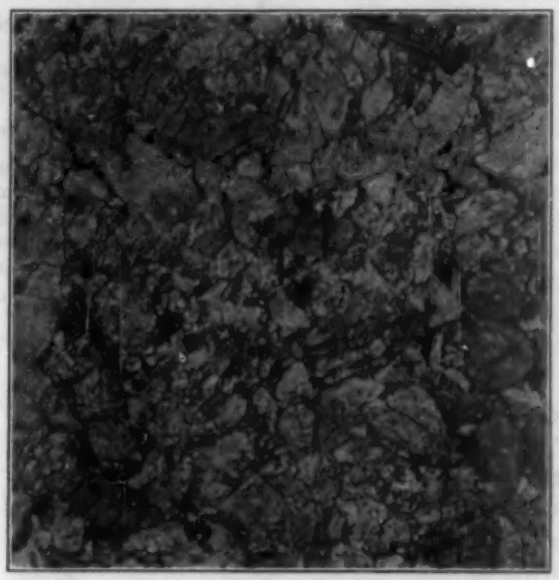

FIG. 7.—Structure of ware made from clay U ground to pass 4-mesh; specimen fired to cone 14.

If two clays are available, one subject to expansion and the other not, they could be blended, using the one showing expansion for the fine and the other as the coarse ingredient. This might introduce some complications in grinding and storage, but it is feasible in certain instances.

With the newer presses and the advent of de-airing, forming pressures of 6000 pounds per square inch and higher are attainable and offer a means of reducing the extent of expansion. Phillips[7] and others have shown that oxidizing atmospheres and a slow rate of firing are effective in combating this tendency. These two possibilities, together with grinding control and increased forming pressures, should enable one to make brick that are free from the tendency to expand from any of the clays studied in this investigation.

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[11] F. R. Henry, "A Study on Crushing of Nonplastics in Dry Pressing," *Jour. Amer. Ceram. Soc.*, 19 [9] 235–39 (1936).

THE EFFECT OF TEMPERATURE ON THE STRUCTURE OF SOAPSTONE*

By Hewitt Wilson† and J. A. Pask‡

Abstract

Samples of soapstone from a deposit in the Cascade Mountains of Washington were heated to various temperatures, draw trials were made, and the effect of temperature on the structure and texture was studied microscopically. The results obtained indicate a change of the talc to enstatite at about 1000°C, with a further change to clinoenstatite at about 1200°C. At the higher temperatures iron impurities have united with silica, probably to form fayalite along the original impure schistosic planes of the soapstone.

I. Raw Material

The deposit of massive soapstone[1] used in this study has been described by Wilson and Pask.[2] The authors wished to determine the changes that occur with heating, for soapstone is used in the natural state as a refractory lining in sulfate-recovery furnaces of the pulp and paper industries.[3]

It is a massive schistosic rock showing interbedded darker green streaks which probably result from concentration of iron impurities along these planes in the form of chloritic minerals. Traces of pyrite and magnetite also are usually associated with these streaks.

II. Previous Investigations

A megascopic description of the changes occurring with temperature rise was presented by Wilson and Pask.[2] Ewell, Bunting, and Geller,[4] working on powdered samples and employing petrographic and X-ray methods, determined that talc decomposed to enstatite, amorphous silica, and water-vapor at 800° to 840°C, that the enstatite gradually changed to clinoenstatite around 1200°C, and that the amorphous silica changed to cristobalite near 1300°C, giving clinoenstatite and cristobalite as the final products.

III. Method of Experiment

Specimens, approximately 2 by 2 by 1 inch, were cut from a large block of soapstone. These were cut almost through along one edge so that a suitable slice, 2 by 1 by $^1/_8$ inch, would be available for the preparation of a petrographic slide after firing, since the fired soapstone has a hardness of about 6.0. An oil-fired furnace was used, and the pieces were drawn successively at various temperatures ranging from cone 022 (585°C) to cone 19 (1515°C) and allowed to cool rapidly in air. Cone 19 was reached in about 7 hours. Thin sections were prepared and examined microscopically, and photomicrographs of the more significant changes were made.

IV. Results

From a petrographic study of the thin sections, the following general conclusions were determined. At about 700°C the original pyrite in the soapstone changed to pyrrhotite, and streaks of iron stains, usually associated with the pyrrhotite and chloritic minerals, began to appear which were a result of the dissociation of the iron-bearing minerals. With rise in temperature the iron stains increased.

At about 1000°C a general recrystallization had occurred in the mass of the material, and enstatite crystals appeared. Black slag, containing remnants of the original pyrrhotite and blowholes, was also spreading dendritically, and the section was acquiring a yellowish color. At about 1200°C blockier crystals, probably clinoenstatite, appeared, and the dendritic growth of the slag was more prominent.

Little further change was then apparent until about 1400°C, when the mass began to transform into a melt with some of the original crystals still persisting as ghosts. Furthermore, a second-

* Received April 5, 1937. This report gives the results of work done under a coöperative agreement between the Northwest Experiment Station, U. S. Bureau of Mines, and the College of Mines, University of Washington, Seattle, Wash. Published by permission of the Director, U. S. Bureau of Mines (not subject to copyright).

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‡ Research fellow, Univ. of Washington, 1934–35.

[1] Obtained through the courtesy of the Skagit Talc Company, Inc., of Skagit County, Wash.

[2] Hewitt Wilson and J. A. Pask, "Talc and Soapstone in Washington," *Amer. Inst. Mining Met. Engrs.*, Contrib. No. 99, 25 pp. (1936); *Ceram. Abs.*, **16** [7] 222 (1937).

[3] J. A. Cunliffe and H. E. Clem, "Refractories for Use in Sulfate-Recovery Furnaces of the Pulp and Paper Industries," *Jour. Amer. Ceram. Soc.*, **15** [6] 321–33 (1932).

[4] R. H. Ewell, E. N. Bunting, and R. F. Geller, "Thermal Decomposition of Talc," *Jour. Research Nat. Bur. Stand.*, **15** [5] 551–56 (1935); R. P. 848; *Ceram. Abs.*, **15** [2] 76 (1936).

FIG. 1.—Crossed-nicols; unfired soapstone featuring chloritic streak; ×116.

ary recrystallization had also occurred along the old impurity planes in the original material, the new crystals probably being fayalite. With further increase of temperature the mass became more opaque, and the formation of fayalite along the cracks was more pronounced. The birefringence of the mineral was found to decrease with an increase of temperature.

Six photomicrographs were selected to picture the main changes as outlined above. The magnification was ×116. The first four are taken with crossed-nicols; the last two with plane polarized light.

Figure 1 shows a sample of unfired soapstone. The dark streak represents chloritic material with inclosed flakes of talc and a few small pieces of pyrite and magnetite. Fine, flaky talcose material is working into the edges of the band and is disseminated throughout it, a strong indication that the soapstone was metamorphosed from chloritic rock. The streak is featured in the photograph. In general, however, very little chloritic material can be seen although the magnification is fairly large; thus, a wrong impression must not be gained concerning the degree of purity of the rock. This procedure of bringing out the most outstanding changes regardless of relative abundance is carried out throughout all the photomicrographs.

FIG. 2.—Crossed-nicols; 950°C, indicating growth of iron stains; ×116.

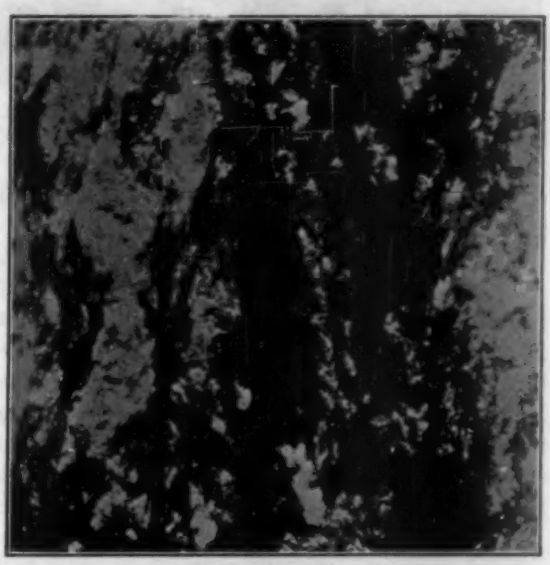

FIG. 3.—Crossed-nicols; 1030°C; appearance of crystals of enstatite with growth of black dendritic slag; ×116.

Figure 2 shows a section heated to 950°C (cone 08). The growth of iron stains with increase of temperature is indicated by the ragged black streak on the left side. The black spot at the lower right is pyrrhotite, evidently derived from the original pyrite. The dense, flaky structure of the rest of the mass is brought out.

Figure 3 shows a section heated to 1030°C (cone 04). A general recrystallization of the mass has occurred. Larger crystals of enstatite have formed and exhibit parallel extinction. Black dendritic slag is working into the talcose

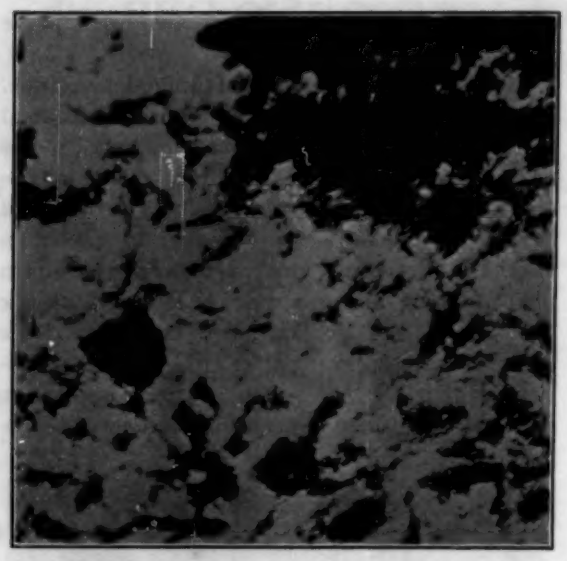

FIG. 4.—Crossed-nicols; 1210°C; appearance of clinoenstatite with further growth of black dendritic slag; ×116.

mass. The (black) iron stains are appearing in greater quantities.

Figure 4 gives a section heated to 1210°C (cone 5). The actual slide shows definite recrystallization, which is not clearly shown in Fig. 4. Blocky crystals, having a small extinction angle, have appeared and are probably clinoenstatite. Dendritic slag is working its way into the ground mass; these growths are usually associated with small holes indicating gas evolution. The whole section has acquired a yellowish appearance.

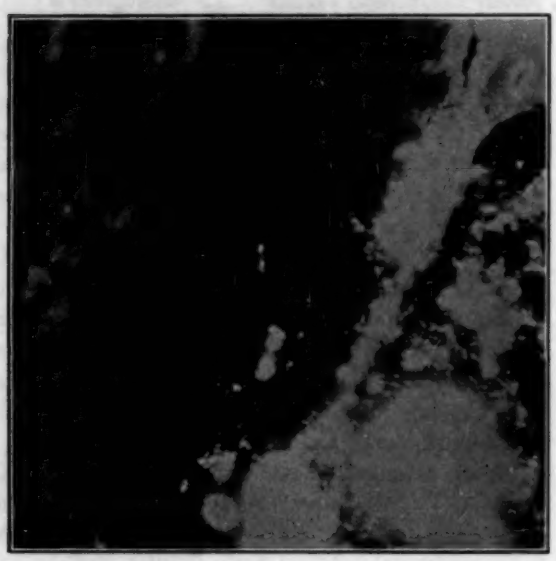

FIG. 5.—1410°C; recrystallization occurring along cracks with a melt appearing in the mass; ×116.

Figure 5 is a section heated to 1410°C (cone 14). A recrystallization is seen along the cracks and blowholes. The darkest material in the center of the recrystallized zone actually is a very dark, amorphous-appearing, reddish iron stain which may be a high-iron siliceous slag whose cooling rate was too rapid to allow crystallization. The new crystals are yellowish brown and needlelike, probably fayalite. The body of the specimen is changing into a melt with the ghosts of some of the former crystals still apparent, and it is becoming opaque. According to the CaO–SiO_2 phase diagram, clinoenstatite has an incongruent melting point at 1557°C, changing to forsterite and a liquid. This may be the case here, the melting temperature being lowered because of the

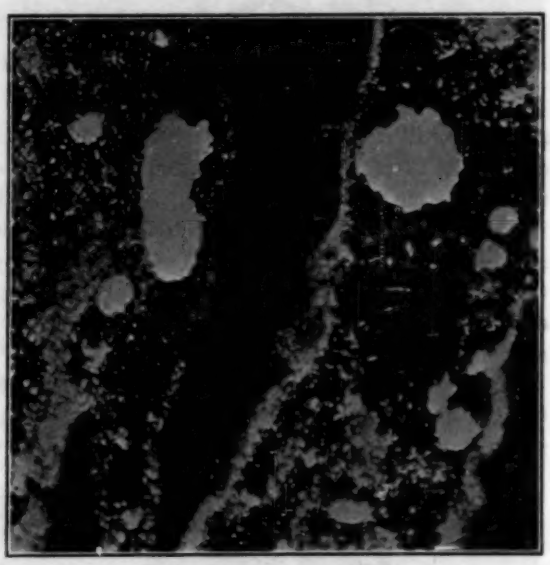

FIG. 6.—1430°C; further growth of crystals and appearance of blowholes along original iron streaks; ×116.

presence of iron oxides, which act as fluxes. This appearance may also be due to the presence of clinoenstatite in a melt of iron silicates that have softening temperatures from 1110° to 1280°C.[5]

Figure 6 is a section heated to 1430°C (cone 15). Crystal growth and blowholes are seen along the original iron streaks. The darkest crystals are brown and needlelike, probably fayalite. The light material is a lighter brown and microcrystalline in nature. The mass of the specimen shows a change to an opaque melt which com-

[5] H. O. Hofman, "Temperatures at Which Certain Ferrous and Calcic Silicates Are Formed in Fusion," *Trans. Inst. Mining Engrs.*, **29**, 682 (1899).

prises most of the sample. The section has become dark grayish.

V. Conclusions

The fact that the temperatures presented here in heating soapstone do not agree with those of Ewell, Bunting, and Geller[4] with pure talc can be attributed to the presence of different conditions. The samples in this study were not held at the temperatures at which they were drawn and they were cooled rapidly. A gradational appearance was shown across the cross-sections of the 1/8-inch slices, indicating that an equilibrium was not present. Furthermore, Ewell, Bunting, and Geller[4] worked with powders, whereas this work was done on the original, massive soapstone.

A large endothermic effect[3] was present from 860° to 953°C. Therefore, since the temperature of the soapstone was not held in this range there probably was a lag in the rate of growth of crystals stable at that temperature, which would otherwise appear with longer constant heating. This would explain the discrepancy of temperatures for the appearance of enstatite. Because no endothermic effects have been found in changing to clinoenstatite, the appearance of this mineral in both studies at approximately the same temperature would be expected.

Talc, a soft material, changes in firing to a much harder material, enstatite and clinoenstatite, having a hardness of 5.5 to 6.5, without any apparent disruption or disintegration of the material. One difficulty to be avoided in the use of such materials is the presence of too much of the iron-bearing minerals, which form a slag at low temperatures and weaken the soapstone in use. In the fired talc specimens, cracking or splitting has also been found to occur along the foliation planes that were darker than the mass, evidently streaks of much higher iron content. These were probably due to differential expansion causing disruption.

Acknowledgments

Grateful acknowledgment is given to H. F. Yancey, supervising engineer of the Northwest Experiment Station of the U. S. Bureau of Mines, for assistance and encouragement, and to G. E. Goodspeed of the Geology Department of the University of Washington, who assisted in the petrographic interpretations.

COMPARISON OF THE THERMAL CONDUCTIVITY AND THERMAL EXPANSION OF COKE-OVEN LINERS MADE FROM EASTERN AND WESTERN QUARTZITE*

By J. B. Austin, R. H. H. Pierce, Jr., and Walter O. Lundberg

Abstract

The results of a set of comparative measurements of thermal conductivity carried out on "eastern" and "western" silica coke-oven liners made by the same process show that the western brick is the better conductor by approximately 15%. This difference is quantitatively explained by the difference in porosity between the two kinds of brick. Only minor differences in thermal expansion were found.

I. Introduction

The chief sources of the ganister used in this country for making coke-oven liners are the Tuscarora formation of Pennsylvania, the Baraboo formation of the Devil's Lake region in Wisconsin, and the Weisner formation of Alabama. The first two are the most important and are commonly described as the "eastern" and "western" quartzites, respectively. For some reason, there is an appreciable difference in the behavior of these ganisters during firing so that a brick made from one differs in a number of respects from a brick made from the other, even though the manufacturing process is identical. For example, the porosity of brick made from western quartzite, which for convenience is called "western brick," is in general a few per cent less than that of "eastern brick" made by the same process. Inasmuch as coke-oven liners of both kinds are on the market, it is interesting to see to what extent they differ in thermal conductivity and thermal expansion and to find out to what extent any differences observed are significant in coke-oven design and operation.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Refractories Division). Received April 16, 1937.

(1) Samples

Several typical samples of each kind of liner were used which were made by a process as nearly the same in each case as commercial manufacturing conditions permit.[1] The porosity of the samples used in these tests, which are representative of the respective groups as a whole, is given in Table I; the difference shown is typical of the average difference in porosity for the two types of brick.

II. Results

(1) Thermal Conductivity

The determination of thermal conductivity was made in a Wilkes-type apparatus.[2] The reproducibility of this apparatus is approximately ±5%, and although the absolute accuracy of the results obtained with it has not as yet been definitely established, there is no doubt that it gives relative values of an accuracy approaching the limit of reproducibility. The test samples were blocks 9 by 4½ by 2 inches, each cut from a separate liner. Two brick of each type were tested and check runs were made on each brick.

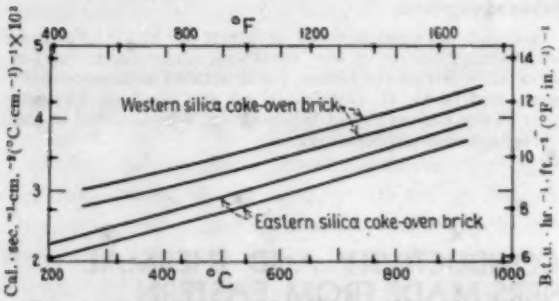

FIG. 1.—Data showing the relative thermal conductivity of coke-oven liners made from eastern and western quartzite by the same process.

The results are shown in Fig. 1 in the form of two bands, each of which covers the observed variation in conductivity for one type of brick, *i.e.*, each band covers the variation observed between check runs as well as any difference between the two samples tested. The width of these bands corresponds to about 10% of the magnitude of the conductivity, as is to be expected since the limit of reproducibility is ±5%.

These data show that over the temperature range investigated the thermal conductivity of the western brick, which has the lower porosity, is consistently greater than that of the eastern brick, a qualitative result which is entirely in accord with expectation because it is now well established that the thermal conductivity of a given refractory material increases with decreasing porosity. There remains, however, a question as to whether this characteristic difference in thermal conductivity, which at 500°C amounts to approximately 0.0005 c.g.s. unit or about 17%, is due solely to the difference in porosity or whether some other factor is also involved. In order to settle this question, it is necessary to know quantitatively the effect of a change in porosity on the thermal conductivity of silica brick; thus, if a decrease in porosity from 26 to 22% increases the thermal conductivity at 500°C by approximately 0.5×10^{-3} c.g.s. unit or by 17%, it may be concluded that the difference in conductivity is directly due to the difference in porosity; whereas if the change in conductivity differs appreciably from 17%, it must be inferred that some factor other than porosity is influencing the thermal conductivity.

TABLE I

TRUE POROSITY OF SAMPLES TESTED

	Brick in thermal conductivity tests (%)		Brick in thermal expansion measurement (%)
	Sample A	Sample B	
Western brick	22.6	22.0	21.8
Eastern brick	25.4	26.0	27.5

Fortunately, the desired information is avail-

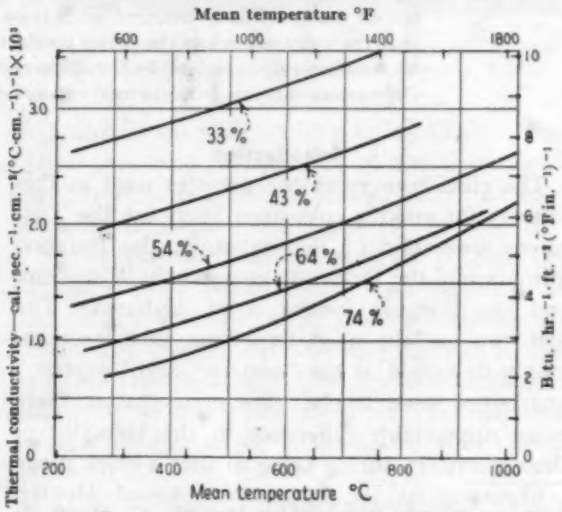

FIG. 2.—Curves showing the thermal conductivity of a set of silica brick of graded porosity.

[1] The samples were obtained through the courtesy of R. P. Heuer, General Refractories Company.

[2] J. B. Austin and R. H. H. Pierce, Jr., "Reliability of Measurements of Thermal Conductivity of Refractory Brick," *Jour. Amer. Ceram. Soc.*, **18** [2] 48–54 (1935).

able from a series of measurements which the writers have made on a set of silica brick of graded porosity.[3] These brick were made under controlled conditions so that the only variable in the set is porosity. The conductivity of these brick, as determined in the same apparatus used in the tests on the coke-oven liners, is shown in Fig. 2. Because the experimental data do not include a porosity below 33%, it is necessary to extrapolate

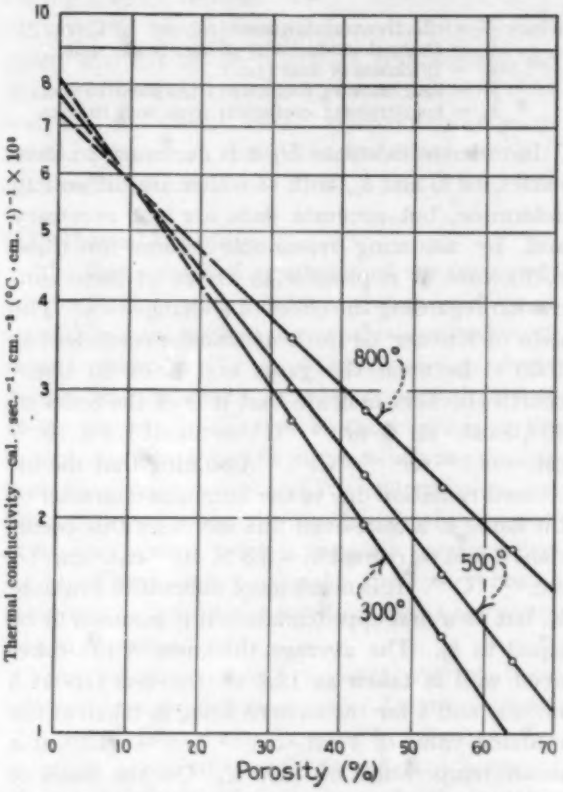

FIG. 3.—Graph showing the isothermal variation of thermal conductivity with porosity in the graded series of silica brick.

to 26 and 22%, the respective porosity of the eastern and western coke-oven liners. Such an extrapolation is rather difficult to carry out on the data in the form given in Fig. 2, but it has been found that if the conductivity of each brick at a given temperature is plotted on a logarithmic scale against porosity on a linear scale, the resulting curve (Fig. 3) is a straight line which may be extrapolated with some assurance.

The porosity axis in Fig. 3 has been cut off at 70% to indicate that it is not permissible to extrapolate the straight lines beyond this point, for even at 80% porosity marked deviations occur, especially in the lines for temperatures above 500°C. It has also been found that the linear relation between porosity and the logarithm of thermal conductivity is not a general one but appears to be characteristic of silica only; consequently, quantitative conclusions drawn from Fig. 3 can not be applied to materials other than silica except as a very rough approximation.

The actual values for the thermal conductivity of the silica brick of the test series are considerably higher than those for the coke-oven liners; but this discrepancy, which may be due to differences in any one of the many variables present in the manufacturing process such as the time and temperature of firing, is not of great consequence because we wish to know the change of conductivity with porosity rather than an absolute value. From the extrapolated portion of the line for a mean temperature of 500°C, it is found that the conductivity is 3.7×10^{-3} c.g.s. units at 26% porosity and is 4.2×10^{-3} c.g.s. units at 22% porosity; that is, lessening the porosity from 26 to 22% raises the conductivity by 0.5×10^{-3} c.g.s. unit or 13.5%. This value is so close to the difference in conductivity of the two types of coke-oven liner that unless the agreement is pure coincidence, which seems unlikely, there can be little doubt that the greater conductivity of the western brick is almost entirely due to its lower porosity. The cause of the difference in porosity is another and more complex problem which is not considered here.

As a consequence of their higher thermal conductivity, the particular western brick tested are, from the standpoint of efficient heat transfer, more desirable for use in a coke-oven wall than the eastern brick with which they are compared. Moreover, since this difference seems to be due entirely to the difference in porosity, which seems to be characteristic of these two types of brick as they appear on the market, the writers feel justified in extending this conclusion to the extent of stating that in general the western brick are better for this purpose. A more accurate statement is that the western brick are the more desirable as long as they continue to have the lower porosity; the manufacturing process can, and at some time may, be changed, with the result that the porosity of brick made from eastern ganister may be lessened or that of brick made

[3] The brick were obtained through the courtesy of Fred A. Harvey, Harbison-Walker Refractories Co.

from the western quartzite may be increased, in which event the advantage will be with the brick of lower porosity whichever that happens to be. This conclusion is strictly applicable only to brick as shipped, because changes occurring during service which alter the porosity may cause a considerable change in conductivity. As the brick become equilibrated under service conditions, the differences between them gradually disappear and in time the advantage of the western brick may be lost. Nevertheless, the approach to equilibrium

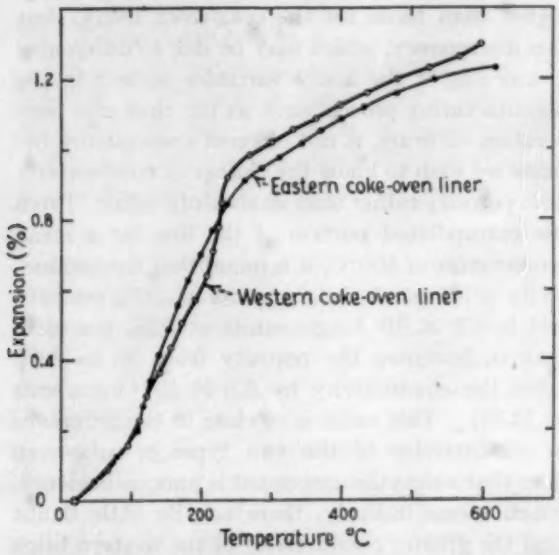

FIG. 4.—Data showing the thermal expansion of two coke-oven liners made by the same process but using different raw materials.

is relatively slow and this advantage probably persists for a very long time after the brick are installed.

Even at first, however, the advantage of the western brick is not so great as the difference of 17% would indicate. In the first place, this value represents the difference in thermal conductivity at a mean temperature of 500°C, which, although a convenient temperature for the comparison with the conductivity of the brick of graded porosity, is much less than the mean temperature of the liner in service. The difference at 1000°C, which is nearer to the mean temperature of a coke-oven wall is somewhat less than at 500°C, because the eastern brick has a slightly higher temperature coefficient of conductivity than the western brick. A more important reason, however, is that the coke-oven liner is only one part of the total thermal circuit, which also includes the effective thermal resistances in transferring heat from the flue gases to the wall and in transferring the heat from the wall to the coke. A more useful estimate of the effect of a change in thermal conductivity of the liner itself is therefore obtained by considering the over-all transmittance of the oven wall, which is given by the relation

$$U = \frac{1}{\frac{L}{k} + \frac{1}{h_f} + \frac{1}{h_c}}$$

Where U = effective transmittance (cal.·sec^{-1}·°C·cm.$^{-1}$).
k = thermal conductivity of liner (c.g.s. unit).
L = thickness of liner (cm.).
h_f = heat-transfer coefficient from flame to wall.
h_c = heat-transfer coefficient from wall to coke.

In order to calculate U, it is necessary to have values for h_f and h_c, both of which are difficult to determine, but accurate data are not necessary and, by assuming reasonable values for these coefficients, it is possible to arrive at some conclusion regarding the effect of a change in k. The data of Kistner[4] on the heat-transfer coefficient at 1600°C between the gases and brick in open-hearth checkers indicate that it is of the order of 40 kilocal. · m.$^{-2}$ · hr.$^{-1}$ · °C^{-1} or about 1.1×10^{-3} cal. · cm.$^{-2}$ · sec.$^{-1}$ · °C^{-1}. Assuming that the increased radiation due to the luminous character of the flame in a coke-oven flue increases this coefficient 3-fold we can set $h_f = 3.3 \times 10^{-3}$ cal. · cm^{-2} · sec.$^{-1}$ · °C^{-1}. It is much more difficult to evaluate h_c, but as a first approximation it is assumed to be equal to h_f. The average thickness of the coke-oven wall is taken as 12.5 centimeters (about 5 inches) and k for the eastern brick is taken at the rounded value of 4 cal. · cm.$^{-2}$ · sec.$^{-1}$ · °C^{-1} at a mean temperature of 1000°C. On the basis of these values,

$$U = \frac{1}{\frac{12.5}{4} + \frac{1}{3.3} + \frac{1}{3.3}} = \frac{1}{3.72} = 0.269 \text{ cal.} \cdot \text{cm.}^{-2} \cdot \text{sec.}^{-1} \cdot {}^{\circ}\text{C}^{-1}$$

If k is increased by 13%, the difference between the conductivities of the eastern and western brick at a mean temperature of 1000°C is

$$U = \frac{1}{\frac{12.5}{4.51} + \frac{1}{3.3} + \frac{1}{3.3}} = 0.297 \text{ cal.} \cdot \text{cm.}^{-2} \cdot \text{sec.}^{-1} \cdot {}^{\circ}\text{C}^{-1}$$

That is, an increase of 13% in k increases U by 0.028 unit which is only 10.5%. Should h_c be smaller than h_f (say equal to $h_f/2$), the advantage is somewhat less, for an increase of 13% in k then

[4] Kistner, *Archiv. Eisenhüttenwesen*, **3**, 751 (1929/30).

leads to an increase in U of but 9.2%, which, however, is still appreciable. As a matter of fact, the greatest thermal resistance in the oven is probably in the coke itself, that is, it is probably more difficult to get heat through the coke than to bring heat up to it, but any advantage that can be gained at any point in the thermal circuit is decidedly worthwhile in view of the enormous amount of heat to be transferred in the course of coking a batch of coal.

It should be emphasized here that the values given are not to be taken as representing accurately the heat transfer in an actual coke-oven wall but are merely rough approximations made for the purpose of illustrating the influence on U of a variation in k.

(2) Thermal Expansion

The linear thermal expansion of specimens cut from a liner of each kind was determined by an interferometric method previously described[5] with results shown in Fig. 4. The expansion of the eastern liner is somewhat more regular than that of the western brick, that is, the increase at the inversion points is not so rapid, which in principle is an advantage in favor of the eastern brick, but the differences are slight and the total expansion of the two kinds of brick is so nearly the same that for most engineering purposes the two types of brick can be considered identical as far as dilatation is concerned.

From a scientific point of view, however, these relatively minor differences are of some interest. The magnitude of the increase in length at the inversion temperatures of the different forms of silica indicates that the western brick contains more cristobalite and more quartz than does the eastern liner, which appears to be chiefly tridymite. This distribution of the constituents is confirmed by examination of thin sections under the microscope, which demonstrates beyond question the presence of an appreciable amount of quartz in the western brick. The Baraboo quartzite appears, therefore, to transform more slowly than the Tuscarora quartzite, which is in accord with a conclusion previously reached by Ross.[6]

The comparisons made on the basis of the thermal expansion measurements are clearly valid only for the particular pair of brick studied, and the conclusions drawn from them can not be generalized to the same extent as the data on thermal conductivity. For the difference in conductivity is due to a difference in porosity which, qualitatively at least, is characteristic of practically all eastern and western liners as they appear on the market, whereas any dissimilarity in thermal expansion arises from a difference in the relative amounts of the several forms of silica present. No generalization can be made on this, however, because the coke-oven liners on the market show considerable variation in this respect.

III. Summary

The liner made from Baraboo quartzite is a better conductor than the liner made from Tuscarora quartzite by the same process. The difference in conductivity, which is approximately 17% at 500°C and 13% at 1000°C, is quantitatively accounted for by the characteristic difference in porosity between the two types of brick. From the point of view of efficient heat transfer, the western brick is the better, although its advantage is not so great as the difference in conductivity might indicate, because the liner is only one of several thermal resistances in the total thermal circuit.

The western brick also has a slightly higher thermal expansion between room temperature and 500°C, but the difference between its dilatation and the expansion of the eastern brick is so small that it can be neglected for most purposes. The data show that the western quartzite transforms somewhat more slowly than the eastern quartzite.

Acknowledgment

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[5] J. B. Austin, "Thermal Expansion of Some Refractories," *Jour. Amer. Ceram. Soc.*, **14** [11] 795–810 (1931).

[6] D. W. Ross, "Silica Refractories: Factors Affecting Their Quality and Methods of Testing Raw Materials and Finished Ware," *Bur. Stand. Tech. Paper*, No. 116, 84 pp. (1919); p. 67.

REVIEW OF CERAMIC MATERIALS FOR HIGH-FREQUENCY INSULATION*

By Hans Thurnauer

Abstract

The requirements of physical properties for high-frequency insulators are outlined. The three groups of ceramic materials especially suitable for high-frequency insulation are steatite, cordierite, and rutile bodies. The properties and manufacturing problems in connection with these three groups of materials are discussed.

I. Introduction

The rapidly growing use of short waves and ultra-short waves for high-frequency applications confronts the manufacturer of electrical insulating materials with new problems. As frequencies increase, dielectric losses gain importance. The dielectric-loss factor of an insulating material becomes the determining factor of its usefulness in high-frequency circuits.

II. The Loss Factors

(1) Definition

The dielectric-loss factor of a material is the product of its dielectric constant and the tangent of its loss angle.[1]

Any insulating material between two electrodes constitutes a capacitor. If such a condenser of the capacity, C, is subjected to the potential, E, of a radio-frequency field having the frequency, f, a current, I, will flow through the condenser. If we introduce the angular velocity $\omega = 2\pi f$, then $I = E\omega C$, and the energy to charge the condenser is $EI = E^2\omega C$. The energy actually used in the condenser and transformed into heat is given by the equation

$$N = E^2\omega C \tan \delta$$

Where δ = loss angle
$\tan \delta$ = dielectric power factor
$(90° - \delta)$ = phase difference between current and voltage at the condenser.

The formula shows that for a given potential and capacity, the power factor has to be extremely small in order to keep the product $E^2\omega C \tan \delta$ small, especially at high frequencies.

(2) Effect

In a high-frequency field, the energy consumed by dielectric loss is transformed into heat. If, for instance, energy is taken from the primary oscillating circuit of a receiver where amplification has not yet taken place, the quality of reception and selectivity are impaired seriously. In transmitters where high potentials are used the development of heat through dielectric losses of the insulating material presents a serious problem. A rise in temperature results in further increase of dielectric loss, and this mutual increase of temperature and power factor leads up to a point where the input of heat is in equilibrium with heat radiation. Before this point is reached, however, complete electrical breakdown of the insulator may have taken place.

III. Vacuum as Insulator in Comparison with Solid Insulating Materials

The ideal insulator for high-frequency work is vacuum or air with a dielectric constant of one and a power factor of zero. Only in rare cases, however, may air or vacuum be used as insulators because most insulators are used for supporting or spacing metallic conductors, and for these cases, the insulator must be solid, rigid, and have good mechanical properties.

IV. Factors Causing Dielectric Losses

Before describing some groups of insulating materials for high-frequency purposes, the chief factors causing dielectric losses in an insulating material should be reviewed. They help to explain why certain ceramic materials are better suited than others to serve as high-frequency insulators.

(1) Ohmic Resistance

Direct conductivity through the dielectric material shows up in the form of dielectric losses (ohmic resistance). This is true both for volume and surface conductivity. For any well-vitrified insulating material, these losses are negligible at room temperature and in dry atmosphere. At elevated temperatures, volume conductivity may cause complete breakdown of the insulator, and under humid conditions surface conductivity

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (White Wares Division).

[1] A.S.T.M. Tentative Standards, A.S.T.M. Designation D150-36T and D951-83T (1936).

may become appreciable. Because an unglazed ceramic material has a microscopically rough surface which permits moisture to settle in a continuous path, a glazed surface is desirable or, where glazing is not possible, impregnation with a moisture-resistant wax or varnish gives good results.

(2) Polarization

Dielectric losses may be caused by the dipole movement of polarized molecules in the electrical field. These losses are important for liquid dielectrics but can be disregarded for solid insulators at normal temperature.

(3) Nonhomogeneity

Nonhomogeneity of the structure of the insulating material may cause dielectric losses. For ceramic insulating material, nonhomogeneity may be defined as the presence of the crystalline and glassy phases in one material. A dielectric of this type has a higher dielectric loss than the components of the mixture, especially if the quotient of the conductivity, G, and the dielectric constant, K, is different for the single components of the mixture.

(4) Oxides

Some oxides, especially those oxides which show excessive electrical conductivity at elevated temperature, cause dielectric losses in ceramic materials.

V. Discussion of Ceramic Materials Used for High-Frequency Applications

Ceramic materials used for high-frequency work can be classified into three groups.

(1) Steatite Bodies

Under "steatite" is understood a group of ceramic materials which is based on the raw material talc or soapstone ($3\,MgO \cdot 4\,SiO_2 \cdot 1\,H_2O$) and contains at least 80% of magnesium silicate in the unfired mixture.[2] Steatite bodies of this definition are fired to vitrification at a temperature of approximately 1400°C. The final products of thermal decomposition of talc heated to 1300°C are clinoenstatite and cristobalite,[3] and in a fired steatite body these crystals can be readily identified.

When steatite bodies were first manufactured in this country and abroad, feldspar was introduced as flux to obtain a vitrified body. Bodies were obtained which were not only mechanically strong but also had excellent dielectric properties. The amount of flux used varied between 10 and 20%, depending upon the firing temperature and the purity of the talc. The dielectric losses of these steatite bodies were considerably lower than those of porcelain. This is explained by the fact that porcelain, containing 25 to 30% of feldspar, consists, after firing, of about 60% crystalline and 40% glassy matter, whereas steatite bodies with a low feldspar content are composed of 10% glassy and 90% crystalline phase.[4]

For further reduction of dielectric loss in steatite bodies, the glassy binder, feldspar, has to be

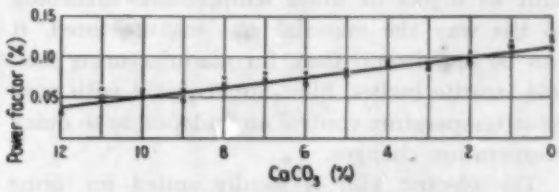

FIG. 1.—Power factor vs. $CaCO_3$ addition to talc. Measurements taken at 1000KC after samples have been dried for 24 hours. Measurements taken on three test pieces for each body.

replaced by other fluxes which either devitrify in cooling or form crystalline compounds by reacting with talc or its products of thermal decomposition. Fluxes of this type are alumina, alkaline earth oxides, or mixtures of various oxides. It is possible to obtain dense bodies without feldspar and some of these new steatite bodies have electrical properties approaching those of quartz glass. As an example, the power factor of pure talc at 1000 KC measures 0.15% and could be reduced to 0.035% for a body containing 12% calcium carbonate as flux (see Fig. 1).

Steatite bodies have the very short vitrification range of one cone. Low-loss bodies of the steatite type are even more difficult to fire because they vitrify within the range of one-half cone. Whereas feldspar starts its fluxing action at its melting point between cones 7 and 9, fluxes introduced in low-loss bodies do not act until the end

[2] E. Albers-Schönberg, "Ceramic Insulating Materials in Radio Applications," *Ber. deut. keram. Ges.*, **15** [4] 199–207 (1934).

[3] R. H. Ewell, E. N. Bunting, and R. F. Geller, "Thermal Decomposition of Talc," *Jour. Research Nat. Bur. Stand.*, **15** [5] 551–56 (1935); R. P. 848; *Ceram. Abs.*, **15** [2] 76 (1936).

[4] E. Albers-Schönberg, "Insulating Materials of the Steatite Group," *Elektrotech. Z.*, **54**, 547 (1933); *Ceram. Abs.*, **13** [10] 267 (1934).

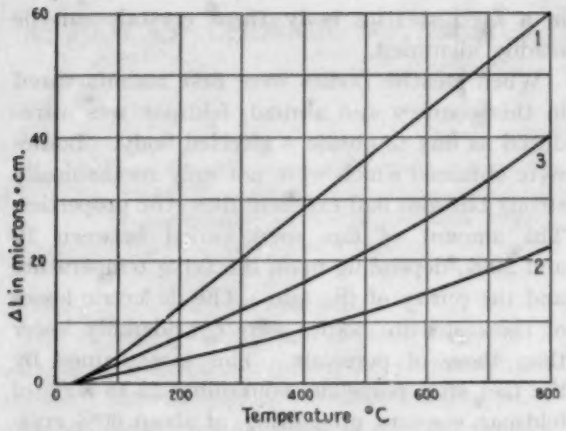

FIG. 2.—Typical linear thermal expansion curves of (1) steatite body, (2) cordierite body, and (3) electrical porcelain body.

of the firing period, which is cones 13 or 14. Considering that the vitrification range may shift to higher or lower temperatures according to the way the material was manufactured, it can be understood that, for manufacturing low-loss steatite bodies, kilns are required with very close temperature control and adaptable to quick temperature changes.

The electric kiln is ideally suited for firing steatite bodies. For this particular application, the present prohibitive cost of electrical firing can be neglected because steatite articles are usually small enough to guarantee efficient loading of the available firing space.

Steatite bodies have a high coefficient of thermal expansion, which is a property of the mineral, clinoenstatite, and is therefore inherent in all bodies which contain clinoenstatite as the predominant compound. Between 170° and 270°C, the well-known cristobalite effect is usually noticeable on the thermal expansion curve except with those bodies in which SiO_2 reacts to form a silicate with the flux of the body (see Fig. 2).

(2) Cordierite Bodies

High thermal coefficient of expansion is an undesirable property where absolute constancy of oscillating circuits has to be maintained. If, for instance, coil forms are made of a material with high coefficient of expansion, oscillators may shift by mere temperature changes due to the physical change of size of the coil form. For such cases, materials with a low coefficient of expansion should be used. Again talc can be used as one of the ingredients for the manufacture of such bodies. This refers to the so-called cordierite bodies. The name indicates that the chief crystalline compound in these materials is cordierite, $2MgO{\cdot}2Al_2O_3{\cdot}5SiO_2$.

A mixture which has the theoretical composition of cordierite consists of 39.6% talc, 47.0% clay, and 13.4% Al_2O_3. A body of this composition, however, has such a short vitrification range that it is impracticable from a manufacturing standpoint, at least where it has to be fired to vitrification. It is necessary, therefore, to reduce the amounts of alumina and talc and make a body containing the maximum amount of cordierite crystals which can still be fired to vitrification.

Cordierite bodies have a rather rough surface, and surface conductivity is therefore likely to occur under humid conditions. Glazing can not be done satisfactorily by ordinary methods, owing to the low coefficient of thermal expansion of

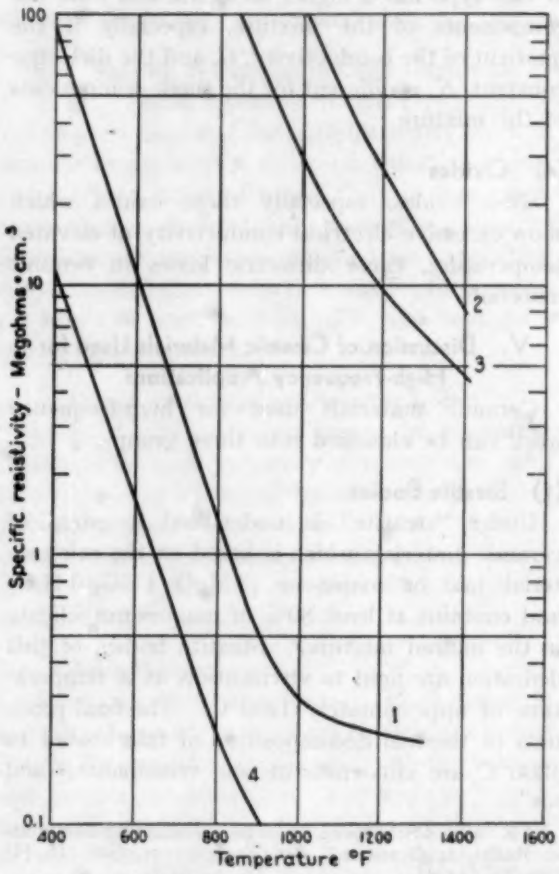

FIG. 3.—Typical specific resistivity curves of various ceramic insulating materials: (1) commercial steatite, (2) low-loss steatite, (3) cordierite body, and (4) electrical porcelain.

these bodies. Invariably the glazes show crazing. If the glazes with low coefficient of thermal expansion are used, crazing does not appear immediately after the pieces are taken out of the fire but can be expected within a short period of time after such an article has been in use.

There exists, however, a method by which cordierite bodies can be glazed successfully. By adding feldspar or other glassforming fluxes to a cordierite body, vitrified materials with a low coefficient of thermal expansion are obtained which develop a self-glaze on the surface during firing. This glaze layer fits to the body without crazing. Its thickness is only 0.001 to 0.002 inch, and it is intimately connected with the body by cordierite crystals extending from the body into the glaze. Despite the fact that a definite tensional strain, parallel to the contact with the body can be observed, showing that the coefficient of expansion of the glaze is greater than that of the body, crazing does not occur because the glaze layer is very thin and the glassy bond of the body is of the same nature as the glaze.

Power factor values of cordierite bodies lie between those of porcelain and steatite and vary slightly with composition. The feldspar content of the glazed articles has some effect on the power factor.

(3) Rutile Bodies

This group of ceramic materials is entirely different in its chemical structure from groups (1) and (2). These are materials having a high dielectric constant.

For high-frequency applications condensers with low dielectric losses and concentrated capacities are desirable; in other words, condensers of high capacity but of small size. These condensers are usually made of mica because it has good electrical qualities and can be obtained in very thin sheets. Mica, however, has some objectionable properties. Its dielectric strength is sufficiently high but, being a natural product, it varies from piece to piece. Mica condensers are also subject to warping with age and moisture, with consequent shifts of capacity during use.

Because of its superior electrical and me-

TABLE I

PROPERTIES OF CERAMIC MATERIALS USED IN ELECTRONIC APPLICATIONS*

Property	Steatite bodies				Cordierite bodies (unglazed)	Rutile bodies (unglazed)	Porcelain	
	Commercial type		Low-loss type					
	Unglazed	Glazed	Unglazed	Glazed			Unglazed	Glazed
Tensile strength (lb./in.²)	6000–8000	7000–9000	6000–8000	7000–9000	3000–4000	6000–8000	1500–3000	2000–4000
Compressive strength (lb./in.²)	60,000–80,000	70,000–100,000	60,000–80,000	70,000–120,000	30,000–50,000	40,000–80,000	100,000–120,000	100,000–120,000
Modulus of rupture (lb./in.²)	18,000–22,000	20,000–24,000	18,000–22,000	20,000–24,000	7000–12,000	18,000–22,000	6000–13,000	4000–17,000
Linear coefficient of thermal expansion 20°–600°C (mm./m°C)	7–9 × 10^{-6}		7–8 × 10^{-6}		2.2–2.7 × 10^{-6}	8–9 × 10^{-6}	3.0–4.5 × 10^{-6}	
Specific gravity (g./cm.³)	2.5–2.8		2.6–2.8		2.1	3.9	2.3–2.5	
Water absorption after 100-hr. immersion (%)	0.0–0.1		0.0–0.1		0.0–1	0.0	0.0–0.2	
Softening temperature (°C)	1430		1420		1400	1500–1550	1300–1500	
Dielectric strength (inst.) (volts/mil.)	180–220		180–220		120–150	150–200	130–150	
Volume resistivity (ohms/cm.³)	68°F: 3 × 10^{14}		Above 10^{14}		Above 10^{14}		Above 10^{13}	
	600°F: 11 × 10^{8}						1.6 × 10^{8}	
	800°F: 14 × 10^{5}						22 × 10^{4}	
	1000°F: 3 × 10^{5}		11 × 10^{5}		32 × 10^{5}			
	1200°F: 22 × 10^{4}		27 × 10^{5}		98 × 10^{4}			
	1400°F:		84 × 10^{4}		46 × 10^{4}			
Dielectric constant	5.5–6.5		5.5–6.5		5.0–5.5	80–100	5–6.5	
Capacity change for 1°C between 20 and 80°C (10⁶)	+1.2 to +1.6		+1.2 to +1.6			−7.0 to −7.4	+5.0 to +6.0	
Dielectric power factor	100 KC: 0.24–0.20		0.06–0.05		0.70–0.40	0.15–0.10	1.2–1.5	
Dry atmosphere (%)	1000 KC: 0.20–0.18		0.06–0.04		0.50–0.30	0.10–0.06	0.7–1.2	

* These data have been compiled from measurements carried out by the author from values given by manufacturers and found in references. They do not apply to any one material but, as the wide range of properties in some cases indicates, materials in the same classification vary considerably. Measurements by the author have been obtained by A.S.T.M. test methods.

chanical properties, steatite has been suggested as a dielectric for condenser work. As high-capacity condensers made of ordinary ceramic materials with a dielectric constant of 6 to 8 are relatively bulky, they are not used in radio construction where space is limited.

There exists in nature a mineral with exceptionally high dielectric constant. This mineral is rutile, TiO_2; its dielectric constant is 183 parallel to its crystal axis and 89 perpendicular to the axis. A crystal mixture has a dielectric constant of 110. By adding fluxes to titanium dioxide, it is possible to produce vitrified ceramic bodies which consist chiefly of rutile crystals. The addition of fluxes causes a decrease of dielectric constant to less than 110.

The power factor of such bodies is low and within the limits of low-loss ceramic materials at high frequencies. At low- and audio-frequencies, however, the power factor increases considerably.

Bodies with high dielectric constant are characterized by a high negative temperature coefficient of capacity, which means that the dielectric constant decreases with increasing temperature. This is in contrast to most solid insulating materials which have a positive temperature coefficient of capacity. For instance, the dielectric constant of porcelain[5] changes from 8 at room temperature to 63 at 100°C.

As the negative temperature coefficient of capacity is a physical property of rutile, temperature-independent dielectrics can be made only by reducing the TiO_2 content considerably and, therefore, at the same time lowering the dielectric constant. It is possible to make bodies which have a dielectric constant within the range of 110 to 6 by changing the amount of TiO_2. Bodies with dielectric constants between 10 to 20 are practically independent of temperature.

Rieke and Ungewiss[6] have described bodies with a dielectric constant of about 18 and a very low temperature coefficient of capacity. Their bodies, consisting chiefly of magnesium titanates and zirconium titanate, sinter together at cone 16. Excellent bodies have been obtained, especially in the magnesium titanate group, with a low power factor and good mechanical properties. The experiments of these investigators have been tried but with little success because vitrified bodies could not be obtained at cone 16, despite the fact that the test disks were pressed under a load of 5000 pounds per square inch. Unfortunately these investigators did not state how they prepared the bodies for pressing and what pressure was used.

VI. Conclusions

Little information can be obtained today upon the practical values of magnesium titanate pieces and on their manufacturing properties. It seems, however, that they have a good future if manufacturing difficulties can be overcome and if firing shrinkages can be reduced to a point where it is possible to make bodies of exact dimensions. The study of titanium dioxide ceramics has just started and the first results obtained are encouraging enough to justify further investigation on the various problems connected with the manufacture of these materials.

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ACID BESSEMER REFRACTORIES*

By J. H. Chesters and R. J. McLean

Abstract

A study has been made of the refractories used in the acid Bessemer process. The failure of the tuyères, which generally precedes that of the remainder of the bottom, is found to be due mainly to the attack of ferrous oxide and manganous oxide. The rapid rate of wear is explained by the fact that an addition of 8% of ferrous oxide or manganous oxide reduces the melting point of the tuyère to 1550°C, *i.e.*, to about the temperature of the molten steel. Laboratory investigations suggest a number of possible ways of increasing bottom life, *e.g.*, the production and use of (*a*) basic tuyères of high spalling resistance, (*b*) plumbago tuyères, and (*c*) fireclay tuyères of higher alumina content.

I. Introduction

The acid Bessemer process consists essentially of blowing air through molten pig iron to oxidize the manganese, silicon, and carbon. Molten iron is poured into a large vessel lined with refractory material and fitted with a detachable bottom through which the air is introduced. The oxidation takes place with such a great evolution of heat that after about twenty minutes the metal attains a temperature of the order of 1550°C.

A new Bessemer bottom (10 feet in diameter), ready to be attached to a 25-ton converter, is shown in Fig. 1.

The tuyères, the tops of which are level with the top of the ramming mass, are about 33 inches long and 6 inches in diameter. In general, there are about thirty such tuyères, each with about ten 1/2-inch diameter holes. The tuyères are so arranged that wear is kept as even as possible over the whole surface of the bottom.

The space between the tuyères is rammed with refractory material. Specially shaped filler blocks designed to facilitate ramming of the space between the tuyères and themselves, are spaced at intervals throughout the bottom to act as reinforcement for the ramming mass. The use of these fillers is in the nature of insurance. Given a sufficiently good ramming mass they become unnecessary, but with normal practice their inclusion eliminates periodical failures in bottom life due to the flaking away of the ramming mass.

At the end of a campaign of about twenty blows of 20 minutes each, during which air is blown through the iron at the rate of 20,000 to 30,000 cubic feet per minute, the bottom has considerably altered (Fig. 2). The vessel lining, which lasts much longer, shows little change after one such campaign. The tuyères have worn back to within a few inches of the plate, while the surrounding ramming mass, although badly worn, is as much as 10 inches higher.

Periodically, one tuyère cuts back much faster than the rest. This action, which is thought to be due to partial blocking of a tuyère hole resulting in a local fall in effective blast pressure, is often referred to as "boring." Under such conditions, a rate of wear of one inch per minute is not unusual. The tuyère in Fig. 3 shows slight signs of such boring.

The life of the bottom varies considerably from plant to plant according to the quality of the iron, the blowing pressure, etc., but a life of 20 to 30 blows is usual with converters of the 25-ton class.

The refractories' costs per ton of steel produced varies from about 10 cents (five pence) to 25 cents (a shilling) per ton of steel produced, while the vessel lining costs correspond to about another ten cents. The destruction of the refractories in a Bessemer converter is all too obvious and gives the impression that this method of making steel involves an abnormally great consumption of refractories. In point of fact, the costs are only about one-half of the corresponding costs for open-hearth furnaces, the latter often amounting to a much as $1.00 (four shillings) per ton of steel produced.

II. The Converter Lining

The shell of the converter is usually lined either with a micaceous sandstone or soft-fired silica brick. Ordinary silica brick, as employed for open-hearth furnace construction, are unsuitable for this purpose because of their low spalling resistance, but certain silica brick having a specific gravity of about 2.52 and consisting mainly of raw quartz are found to give excellent service.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Refractories Division). Received March 27, 1937.

The joint between the converter shell and the bottom is made by means of a clay-ganister mixture.

III. The Bottom

(1) The Tuyères

From time to time a considerable number of companies have been engaged in the manufacture of tuyères for acid Bessemer converters. The present small demand and the specialized nature of the job has led to two firms only remaining in this line of business. Samples of their tuyères have been obtained and tested in this laboratory.

TABLE I

PROPERTIES OF ACID BESSEMER TUYÈRES

Chemical analysis	British tuyère (%)	American tuyère (%)
SiO_2	57.8	53.7
Al_2O_3	38.1	37.5
Fe_2O_3	0.9	3.1
TiO_2	0.7	2.2
CaO	0.4	0.5
MgO	0.4	1.5
Alkalis	1.0	Not done
P. C. E.	31(1690°C)	31(1690°C)
Porosity (%)	21.0	19.8
Bulk density (g./cm.^{3})	2.02	2.14
Specific gravity	2.56	2.67
Permeability to air (c. g. s. units) (parallel to but excluding tuyère holes)	0.07	0.10
Thermal shock resistance (special test)	60+	60+
Number of reversals required to cause bad fracture	Excellent	Excellent

It will be seen that both tuyères have been made from a fire clay of medium alumina content and have a P.C.E. not much over 100°C above the operating temperature. In both cases the porosity is low while the permeability parallel to but excluding the tuyère holes is moderately high. With certain ladle brick, permeabilities as low as 0.001 c.g.s. unit have been observed.

It is worthy of note that the spalling resistance of both tuyères in the particular test employed was found to be very high. Samples of dimensions 3 by 2 by 2 inches were sawed from the tuyères and placed in a furnace at 900°C. After ten minutes they were removed and placed on a cold brick; after another ten minutes they were replaced in the furnace and the process was repeated until this test piece cracked in half. Many fireclay brick subjected to this treatment crack in half after as few as 15 reversals. Magnesite withstands about 5 reversals, while ordinary silica brick crack during the first heating period. The tuyères tested were quite intact after 60 reversals.

Thin sections cut through the British and American tuyères reveal, under the microscope, the presence of considerable amounts of free quartz. The presence of this mineral in the British tuyère is readily explained by the fact that about 10% of silica rock is added to the tuyère batch to compensate the firing shrinkage of the aluminous clay. Whether this compromise is strictly necessary has not yet been made clear, but it should not be assumed that the presence of this extra silica will necessarily reduce the P. C. E. or the slag resistance at all seriously, since most of the quartz remains as quartz even in the slagged tuyère.

(2) The Filler Blocks

The filler blocks used in the British plant are of an aluminous type, almost identical in composition with the material used in the manufacture of blast-furnace brick. A typical analysis of a filler brick is given below:

	(%)		
SiO_2	55.0	Porosity (%)	22.2
Al_2O_3	40.2	Bulk density (g./cm.^{3})	2.05
Fe_2O_3	3.2	Specific gravity	2.63
CaO	0.5		
MgO	0.7		
Alkalis	1.1		

(3) The Ramming Mass

The British ramming mass at present consists of a mixture of 60% fireclay brick grog and 40% raw clay. The following is a typical overall grading (B. S. I. sieves):

½ to ¼ in. (½ to ¼ in.)	¼ in. to 7-mesh (¼ in. to 0.095-mesh)	7 to 25 (0.095 to 0.024 in.)	25 to 72 (0.024 to 0.008 in.)	72 to 150 (0.008 to 0.004 in.)	Through 150 (Through 0.004 in.)
10%	10%	30%	20%	10%	20%

The average chemical analysis of the above batch is approximately as follows:

	(%)
SiO_2	59.8
Al_2O_3	36.8
Fe_2O_3	2.1
CaO	0.3
MgO	0.5
Alkalis	0.9

Although no particular precautions are taken at present to insure constant grading, samples taken

FIG. 1.—Bessemer bottom ready for the converter.

at frequent intervals show that, provided the same grinding procedure is maintained, the grading of the ramming mass remains extraordinarily constant. The moisture content, which amounts to 8% of the dry batch weight, is carefully controlled.

In the United States, fireclay brick grog or silica rock is used, together with one or more fire clays. Thus in one plant, a mixture of 50% by weight of ganister (through 1/8-inch mesh) and 50% fire clay is employed, while in another plant, 26 parts by volume of ganister are mixed with 15 parts by volume of clay. Certain firms attempt to economize by using a sloppy ramming mass which can be poured into position, thus reducing labor costs. Where this procedure is adopted, the grog used is generally ganister. Such plugs crack badly during drying, but are said to give lives almost, if not actually, equal to those of the semidry rammed plugs.

IV. Drying

The equipment used in drying Bessemer bottoms varies greatly from plant to plant. Certain firms prefer periodic stoves holding one to four bottoms at a time, while others make use of tunnel driers. The time of drying varies from 2 to 4 days and the maximum temperature from about 400° to 900°F. In general, the temperature measured is that of the stove gases. The lower sections of the bottom may, therefore, still contain considerable amounts of water even though the stove temperature has reached 400°F. Whether such moisture has any adverse effect on bottom life has yet to be shown. Very wet bottoms would obviously be dangerous, but bottoms that normally are used only half dry did not give any better life as a result of longer drying periods.

FIG. 2.—Bessemer bottom at the end of a campaign.

FIG. 3.—Bessemer tuyère at the end of a campaign.

V. Operating Conditions

On leaving the drier, the bottom is usually attached as soon as possible to the converter. No further preheating is attempted, the first charge of molten iron coming into direct contact with the relatively cold bottom. Before the converter turns to its working position with the bottom horizontal, the air blast is applied thus preventing metal from blocking the tuyère holes. Numerous attempts have been made to picture the conditions existing at the tuyère ends, but such attempts must of necessity include a good deal of speculation. It is known that the air blast oxidizes the manganese, silicon, and carbon in the charge in addition to some of the iron. The composition of

the finishing slag (example given below) indicates to some extent the processes involved.

Acid Bessemer finishing slags

	(%)
SiO_2	65.0
Al_2O_3	4.0
FeO	12.9
MnO	17.0

The alumina pick-up in the slag corresponds fairly closely to that lost by wear from the refractories. The microscopical examination of a thin section cut through a tuyère end reveals to some extent the mechanism of the attack. The iron and manganese oxides permeate the fire clay until the melting point of the latter has been so reduced that it is readily removed by the swirling slag and metal. The ganister grains appear to show a higher slag resistance than the clay since they float away almost unattacked. This suggests that a silica tuyère would be better from a chemical standpoint than a moderately aluminous fire clay, a conclusion confirmed by laboratory tests. Unfortunately no method is known of making a silica tuyère with a thermal-shock resistance comparable with that of the fireclay tuyères now in use. Sections cut through the finishing slag reveal the presence of quite large pieces of undissolved fire clay, most of which no doubt come from the ramming mass. The temperature gradient through the bottom is very steep, and hence the clay-grog mixture sinters only to a depth of an inch or so behind the working face. This frequently results in the scaling away of large pieces of ramming mass, a process that is aided by lamination produced during ramming.

Under higher magnifications and particularly after reheating and slow cooling, small colonies of what appear to be cross-sections of very minute needle-like crystals can be seen in the slagged surface of the tuyère. Similar crystals appear, together with magnetite and glass in melts formed by the attack of FeO on aluminous fire brick. Their refractive index (1.65 to 1.68), birefringence, shape, etc., suggest mullite.

FIG. 4.—Induction furnace slag tests: (1) British tuyère, (2) ganister, and (3) chrome-magnesite cement.

FIG. 5.—Induction furnace slag tests: (1) fireclay, (2) sillimanite, (3) plumbago (tested for twice normal period), (4) plumbago (untested).

Analysis of the tuyère end shows that FeO and MnO are the principal attacking materials.

ANALYSIS OF SLAGGED TUYÈRE END

	(1) Actual (%)	(2) Corrected for dissolved tuyère (%)
SiO_2	30.8	15.6
Al_2O_3	13.8	
As Fe_2O_3	47.3	73.9
MnO	6.7	10.5

It will be seen from column (2) that the material responsible for the damage to the tuyères appears to be much richer in FeO than the finishing slag. This result is confirmed by X-ray examination which reveals the presence of considerable amounts of magnetite.

Attempts have been made to simulate Bessemer conditions in the laboratory by the use of a small induction furnace. The refractory to be tested was made up in the form of a crucible. A manganese iron of composition similar to that employed in practice was melted in the crucible by induction heating and a hematite slag added. After a given time the charge was poured and the crucible sawed in half and examined for wear. Figure 4 shows the first series of tests in which the slag resistances of the British tuyère, a ganister lining, and a chrome-magnesite lining were compared. The results of this test suggested that silica has a higher slag resistance under the above conditions than an aluminous fire clay and that chrome-magnesite is even better. A second series (Fig. 5), in which the relative slag resistances of an aluminous fire clay, sillimanite, and plumbago (fire

clay containing about 30% graphite) were compared, suggests another possible line of development.

VI. Experimental Tuyères

A number of attempts have been made both in the United States and in Great Britain to develop tuyères of much greater slag resistance. Magnesite, chrome-magnesite, sillimanite, and plumbago are among the materials that have been tried. A number of tuyères were made by ramming magnesite and chrome-magnesite mixtures, bonded either with silicate of soda or *ciment fondu*, into thin sheet-steel cases, suitable pins being held in place to form the tuyère holes. Tuyères made in this way did not last more than half as long as the ordinary fireclay variety. Examination of the tuyères at the end of the campaign suggested that failure was probably due to scaling-off of the surface layers rather than to slag attack. The depth of slag penetration was considerably greater than with fire clay, suggesting that the chemical slag resistance of these materials was definitely greater than that of fire clay.

Plumbago tuyères made from a mixture similar to that used in the small crucible tests were also tried. The preliminary results suggested that these were definitely superior to fireclay tuyères, but their high cost makes it doubtful whether their general use would prove economical.

Laboratory experiments are now being made to obtain more fundamental data regarding the attack of MnO and FeO on fireclay materials. The ternary diagrams, $FeO–Al_2O_3–SiO_2$ and $MnO–Al_2O_3–SiO_2$, are being worked out approximately, while the melting points in a number of binary series, *e.g.*, fireclay tuyère–FeO, etc., are being determined. The following data obtained by heating up mixtures of slag and refractory in the form of cylindrical pills, although only approximate, demonstrate the type of data this process will give.

Mixtures of the British tuyère and FeO (added as ferrous oxalate) when heated up in a gas-fired kiln collapsed at the following temperatures:

British fireclay tuyère (%)	FeO (%)	Collapsed at °C
50	50	1400
60	40	1400
70	30	1380
80	20	1455
90	10	1530
100	0	1690

It is evident from the above data that an addition of about 8% FeO reduces the melting point of the British tuyère below the temperature of the molten metal (about 1550°C). Similar experiments made with china clay suggest that, from a chemical standpoint, this material would be superior because about 13% FeO is required to reduce the melting point to 1550°C.

The melting points of mixtures of 10% FeO with various aluminium silicates from pure alumina to silica brick are also of interest.

Material	Approximate alumina content (%)	Collapse point + 10% FeO (°C)	Collapse point + 10% MnO (°C)
Fused alumina	99	Over 1650	Over 1670
Sillimanite	60	Over 1650	Over 1670
China clay	43	1600	1600
Ladle brick A	37	1540	1560
British tuyère	?4	1570	1570
Ladle brick B	27	1460	1420
Ladle brick C	26	1440	1400
Semisilica brick	9	1490	1500
Silica	1	Over 1650	1670

These data suggest that the most encouraging aluminium-silicate refractories, from the point of view of resistance to FeO and MnO, are those at the high alumina or high silica ends of the diagram.

VII. Conclusions

Numerous factors, such as blowing power, the manganese content of the iron, etc., affect the bottom life quite apart from the refractories used. The present paper discusses only the refractories side of the problem, and the primary need here seems to be the production of tuyères capable of resisting the fluxing action of FeO and MnO at high temperatures. A basic tuyère would meet this demand, but even if it proved possible to obtain a basic tuyère with adequate spalling resistance, the high cost would necessitate a great increase in bottom life. Price is also an obstacle with the plumbago tuyère; it is very doubtful whether the remainder of the refractories would stand up long enough to justify the additional cost even if the plumbago tuyères met the need.

The most encouraging line seems to lie in altering the physical and chemical properties of the aluminium-silicate refractories already in use. Thus, a more aluminous tuyère would probably give better service provided it had good spalling resistance, etc. Any fundamental solution of this problem requires a knowledge of equilibria and reaction rates in the systems $FeO–Al_2O_3–SiO_2$ and $MnO–Al_2O_3–SiO_2$. No such data are at present available, but several workers are concentrat-

ing on these systems and it is hoped that at least approximate data will soon be available.

Acknowledgment

The writers in conclusion wish to express their thanks to T. Swinden and the United Steel Companies, Ltd., for permission to publish these results, and to all those who have supplied them with information and samples.

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IMPROVED APPARATUS FOR MEASURING THERMAL CONDUCTIVITY OF REFRACTORIES AT HIGH TEMPERATURES*

BY J. L. FINCK

ABSTRACT

Improvements which have been made in a thermal conductivity apparatus are described.

I. Introduction

In a previous paper,[1] the writer has described an apparatus for measuring the thermal conductivity of refractories at high temperatures. This apparatus was used for measurements of conductivity of commercial materials, and during its use certain weaknesses developed which have resulted in the improvements to be described.

Referring to the earlier paper, the advantages in the design of the apparatus have been found to be as follows:

(1) The heat flow through the test specimen, the source of which heat is well localized, could be measured easily by means of the electric-power input into the center heater. The heat losses to the edge and bottom heaters are small, and corrections can be applied for these losses.

(2) The area over which this heat is generated is also well defined and, by the use of isothermal surfaces, the density of heat flow as it emerges from the heater and enters the test specimen is quite uniform.

(3) The top and bottom surfaces of the test specimen are each maintained at uniform temperature, and this temperature can be readily measured by fine thermocouples placed on each surface. The temperature difference across the test specimen can also be made small, regardless of the magnitude of the mean temperature. As was pointed out,[1] this leads to accurate measurements of conductivity.

(4) The heat capacity of the entire apparatus is comparatively small, and equilibrium can be reached within a reasonable time.

The difficulties that have been encountered in operating this apparatus are as follows:

(1) The nichrome isothermal plates are inclined to oxidize at the high temperatures and to warp to some extent. This requires occasional grinding.

(2) The electric insulation between the heating elements and thermocouples has not been entirely satisfactory at the high temperatures, and some leakage occurred. This was corrected by taking successive sets of observations with the current in one direction and then with the current reversed. This correction, however, was not entirely satisfactory at the higher temperatures.

(3) The detailed design of the apparatus is such that it is difficult to replace heating elements and thermocouples when they fail.

II. Description of Apparatus

The present paper describes two new sets of apparatus which retain all of the good features of the original apparatus with the unsatisfactory parts eliminated.

The first set of apparatus is shown in Fig. 1. The general arrangement of the heaters is the same as in the original, and the dimensions are practically the same. In this figure, center, edge, and bottom heaters are shown, each of which is covered by a circular silicon-carbide plate, $1/2$ inch thick, which serves as an isothermal surface. The surfaces of these silicon-carbide plates are ground flat. The heaters consist of nichrome wire insulated with porcelain beads and wound

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division). Received April 19, 1937.

[1] J. L. Finck, "Apparatus for Measuring Thermal Conductivity of Refractories at High Temperatures," *Jour. Amer. Ceram. Soc.*, **18** [1] 6–12 (1935).

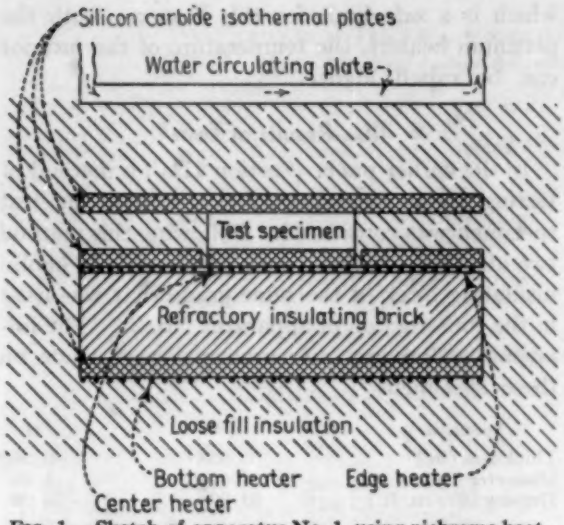

FIG. 1.—Sketch of apparatus No. 1, using nichrome heating elements with silicon-carbide isothermal surfaces.

into spirals. The center and edge heaters rest on a layer of refractory insulating brick, $2^1/_2$ inches thick, which in turn rests on the silicon-carbide isothermal plate of the bottom heater. A three-junction differential platinum-platinum rhodium thermocouple measures the temperature-difference across the surfaces of the insulating brick. A four-junction differential platinum-platinum rhodium thermocouple is also placed in the gap between the center and edge isothermal plates to measure the temperature-difference across the gap. The gap is filled with a loose insulating refractory, the thermal conductivity of which is predetermined.

The test specimen, cut into a flat circular disk from 1 to 2 inches thick, is placed directly on the center plate. If the specimen covers the center area only, a correction has to be applied for the heat flow from the gap.[2] Whenever convenient, the specimen should be cut large enough to cover the gap and reach over the edge heater to some extent to avoid the application of this correction term. Immediately over the test specimen is placed an isothermal plate (see Fig. 1) made of silicon carbide, $^1/_2$ inch thick and ground flat.

At a distance from this top silicon-carbide plate is placed a hollow, bronze, circular plate through which thermostated water passes. The distance between this water plate and the silicon-carbide plate depends on the desired mean temperature of test. The entire apparatus is surrounded with loose, insulating refractory material.

[2] *Loc. cit.*, p. 9.

All of the good features of the first apparatus have been retained. The thermal conductivity of silicon carbide is of the same order of magnitude as that of nichrome used in the original apparatus, and therefore the silicon-carbide plates should serve as isothermal surfaces equally as well as nichrome, with the added advantage over the latter that the silicon carbide does not warp or change in composition appreciably at the temperatures used.

During an extended use of this apparatus, no appreciable signs of electric leakage have been noticed up to temperatures of 1800°F. At higher temperatures a small leakage might occur occasionally, but with the practice of taking successive sets of observations with the current direct and reverse, the effects of this leakage can be eliminated.

None of the individual parts of the apparatus is cemented, and the heating elements and couples can be readily replaced.

The maximum temperature at which conductivity tests can be run in this apparatus are limited only by the type of heating element. Using nichrome, the writer was able to reach about 2000°F, although at that temperature the life of the elements is short.

In order to attain higher temperatures, a platinum heating element was used. The second apparatus is similar to the first, except for a few minor differences. In Fig. 2, the platinum heating elements are set in spiral grooves formed in circular artificial corundum plates, $^1/_4$ inch thick. Each element is covered with a

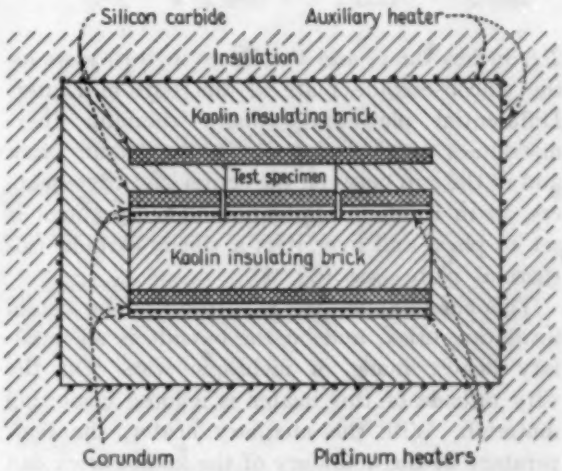

FIG. 2.—Sketch of apparatus No. 2, in which platinum heating elements are used.

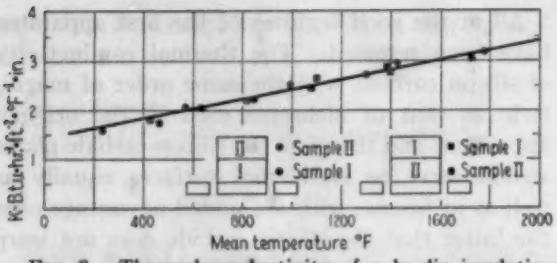

FIG. 3.—Thermal conductivity of a kaolin insulating refractory brick measured in apparatus No. 1; nichrome heaters.

similar corundum plate, which however is free from grooves. Over the latter plates are placed silicon-carbide plates, 1/2 inch thick. The corundum and silicon-carbide plates are ground flat to make good thermal contacts.

The corrugated corundum of the center and edge heaters rests on kaolin insulating brick, 2 1/2 inches thick, and the latter in turn rests on the silicon-carbide plate of the bottom heater. Differential platinum-platinum rhodium thermocouples are installed across the kaolin brick and in the gap between the center and edge heaters, as in the first apparatus. The specimen is set in place and over it is a silicon-carbide isothermal plate (see Fig. 2).

This entire apparatus is surrounded by kaolin insulating brick, and on the outside is an auxiliary heater made of nichrome wire. On the very outside of this heater is a loose insulating material. With this auxiliary heater, the temperature at the boundary of the kaolin brick can be raised to any desired value up to about 1800°F, which is a safe limit for this heater. With the platinum heaters, the temperature of the interior can be raised higher.

III. Results of Tests

In the earlier paper (Section III)[3], a method of testing the normal heat flow through the test specimen was considered. Following this method two identical specimens were prepared from kaolin insulating brick of the same grade that was used in the construction of apparatus No. 2. The following preliminary measurements were made on these specimens:

Specimen	I	II
Thickness (in.)	0.958	0.959
Diameter (in.)	4.44	4.50
Density (lb./cu. ft.)	40.00	39.90

The results of test made on the specimens in apparatus No. 1 are shown in Table I and Fig. 3. In the figure, the dots refer to sample I and the crosses to sample II. The circles surrounding the dots and crosses refer to the tests where sample I was in direct contact with the center heater, and sample II directly over sample I. The squares surrounding the dots and crosses refer to the samples in the reversed position.

In Table II and Fig. 4 are shown the results of tests made on the same samples in apparatus No. 2, which has the platinum heating elements. The designations are the same as in Fig. 3, except that the triangles refer to the samples in one posi-

TABLE I

RESULTS OF TESTS MADE WITH APPARATUS NO. 1; NICHROME HEATERS

Sample I, in direct contact with center heater; sample II, placed on top of I

Sample I				Sample II			
Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)	Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
568.9	356.7	462.8	1.74	350.6	118.8	234.7	1.59
977.4	717.4	847.4	2.22	709.9	429.3	569.7	2.06
1440.3	1154.3	1297.3	2.72	1146.4	837.7	992.1	2.52
1944.7	1613.3	1779.1	3.18	1601.6	1244.7	1423.2	2.95

Sample II in direct contact with center heater; sample I placed on top of II

Sample I				Sample II			
Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)	Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
529.0	320.9	424.9	1.83	723.0	538.2	630.6	2.06
948.0	685.6	816.8	2.22	1193.4	957.6	1075.5	2.48
1242.9	956.8	1099.9	2.66	1516.3	1252.6	1384.5	2.89
1563.3	1235.3	1399.3	2.80	1877.4	1577.3	1727.4	3.07

[3] See III, Theory and Method of Test, *loc. cit.*, p. 7.

TABLE II

RESULTS OF TESTS MADE WITH APPARATUS NO. 2; PLATINUM HEATERS

Sample I, in direct contact with center heater; sample II, placed on top of I

Sample I				Sample II			
Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)	Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
354.9	250.9	302.9	1.50	243.5	139.6	191.7	1.51
744.1	559.2	651.7	2.02	549.7	364.6	457.2	2.01
1221.4	971.2	1096.3	2.17	960.8	702.7	831.7	2.10
1425.2	1151.8	1368.6	2.35	1141.9	855.7	998.8	2.24
1621.9	1413.9	1517.9	2.70	1408.1	1195.3	1301.7	2.[illegible]
1881.1	1652.0	1766.6	2.98	1644.8	1408.6	1526.7	2.90
2044.4	1791.5	1918.0	3.34	1782.9	1521.0	1652.0	3.20

Sample II in direct contact with center heater; sample I placed on top of II

Sample I				Sample II			
Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)	Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
349.3	243.7	296.5	1.76	461.8	363.2	412.5	1.88
627.3	422.1	524.7	1.87	826.3	640.6	733.5	2.06
1031.0	757.4	893.2	2.20	1295.2	1045.9	1170.9	2.42
1235.5	909.1	1072.4	2.34	1548.1	1252.4	1400.2	2.58
1645.7	1367.6	1506.7	2.93	1921.1	1658.1	1789.7	3.09
1787.4	1522.8	1655.1	3.07	2048.9	1799.6	1924.3	3.26
1949.2	1630.8	1790.0	3.20	2237.2	1956.9	2097.0	3.64

tion; and the deltas refer to the samples in the reversed position. In each case the points fall reasonably well on a single curve, which indicates that the lines of heat-flow have been normal through both specimens. In Fig. 5 are shown the curves of Figs. 3 and 4 superimposed. The maximum deviation between the two curves which occur at about 1000°F is 6.2%.

In Fig. 6 are reproduced the results on a silica fire brick as reported.[4] Measurements were made on the same samples in apparatus No. 1 and No. 2, and the results are given in Table III and Fig. 6. The percentage deviations from the original curve are shown in the figure.

[4] *Loc. cit.*, p. 11, Fig. 6.

TABLE III

RESULTS ON SILICA FIRE BRICK AS TESTED IN APPARATUS NO. 1 AND NO. 2

Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. · hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
With Apparatus No. 1			
341.2	155.1	248.2	6.17
1227.7	930.6	1079.2	8.79
With Apparatus No. 2			
543.4	458.6	501.0	7.25
846.3	726.8	786.6	8.16

A sample of silicon carbide which has the same composition[5] as the isothermal plates used in both

[5] In the finished state it has a SiC content in excess of 85% and contains no clay bond, lime, magnesia, or silicate of soda.

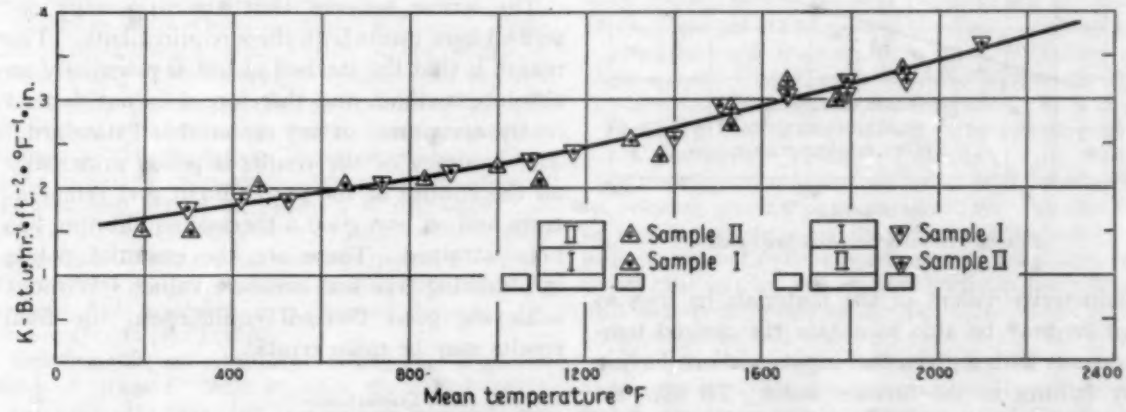

FIG. 4.—Thermal conductivity of a kaolin insulating refractory brick measured in apparatus No. 2; platinum heaters.

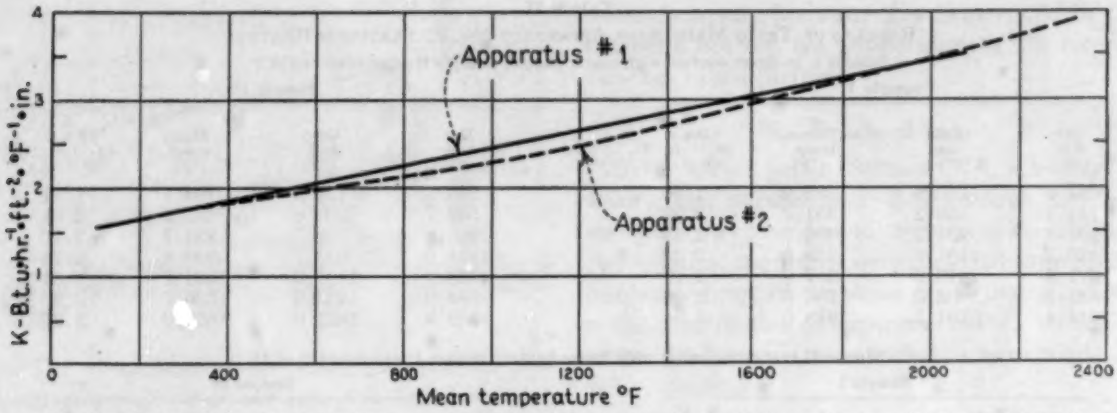

FIG. 5.—Comparison of results of thermal conductivity of a kaolin insulating refractory brick as obtained in apparatus No. 1 and No. 2.

sets of apparatus was prepared for thermal conductivity test. The results obtained are shown in Table IV and Fig. 7.

TABLE IV

CONDUCTIVITY OF SILICON CARBIDE

Hot side (°F)	Cold side (°F)	Mean temp. (°F)	K (B.t.u. hr.$^{-1}$ · ft.$^{-2}$ · °F^{-1} · in.)
216.7	169.3	193.0	46.05
586.6	534.9	560.8	71.6
1027.9	972.3	1000.1	79.0
1302.4	1244.1	1273.2	80.5

IV. Conclusions

In industry the value of the thermal conductivity of refractories is considered from two distinct angles, *e.g.*, that of the engineer who is concerned with the construction and operation of furnaces. He is interested in knowing the true

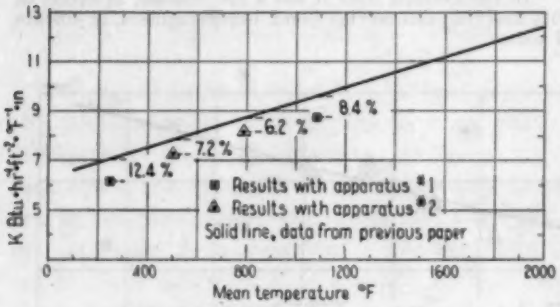

FIG. 6.—Results on silica fire brick.

conductivity values of the materials he uses so that he may be able to obtain the desired temperatures with a given fuel input, without having any failures in the furnace walls. To him, results which are accurate to within 10% may be satisfactory.

Then there is the manufacturer of refractory materials who wants (*a*) to control the uniformity of his product and (*b*) to know the relative value of his product as compared to

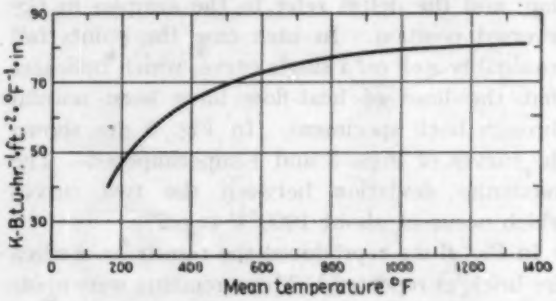

FIG. 7.—Thermal conductivity of silicon carbide.

those of his competitors. Absolute accuracy is not so essential in either case as correct relative values.

The writer believes that the apparatus described here meets both these requirements. The reason is that the method of test is essentially an absolute method, and therefore does not depend on the acceptance of any material as "standard." The accuracy of the results depends principally on the control of the power input and temperatures and on how good a thermal equilibrium has been attained. These are the essential points in obtaining true and accurate values. Without achieving good thermal equilibrium, the final results may be quite erratic.

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CERAMIC ABSTRACTS

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November, 1937

16—11

Abrasives

Artificial pumice stone for polishing. Anon. *Eng. Progress*, **18** [6] 126 (1937).—Quartz is mined, stored in the open to weather for several years, calcined, and reduced to the form of sand. It is then ground, decanted, provided with admixtures, and separated into four grain sizes. The mass of slimy to liquid consistency is poured into molds, dried, and fired in ring kilns. Each of the four grain sizes is fired to three grades of hardness, making twelve grades of stone in all. In the grinding room the stones are cleaned, dressed, and sorted for grain size and hardness. Artificial pumice is said to be superior to the natural material for grinding, polishing, and matting wood, stone, leather, and lacquer surfaces. Illustrated. J.L.G.

Crystal structure of boron carbides. F. Laves. *Nachr. Ges. Wiss. Göttingen, Math.-Physik. Klasse, Fachgr. 4*, [Neue Folge] **1**, 57–58 (1934); *Chem. Abs.*, **30**, 5480 (1936).—The crystals described by Podszus as B_4C occur in trigonal pseudocubic octahedral forms twinned according to the spinel law. X-ray examination shows them to have a rhombohedral lattice corresponding to the hexagonal unit of dimensions $a = 5.62 \pm 0.02$, $c = 12.12 \pm 0.03$ Å; the observed d^{21}_{4} is 2.519 ± 0.001, space group D^5_3d. The hexagonal unit most probably contains 9 formulas of B_4C, a composition agreeing with Ridgway's analysis and preferable over Podszus' formula. See *Ceram. Abs.*, **13** [3] 73 (1934).

Grinding skin and retention of cutting edge of ground parts. F. Rapatz. *Stahl & Eisen*, **57**, 250–52 (1937); *Chem. Abs.*, **31**, 4629 (1937).—Grinding hardened steel frequently causes a soft skin to form about 2 to 3 mm. thick because of the heating in grinding. The skin is particularly noticeable in carburized steel and in alloy steel but not in high-speed steel. Steel with such a skin loses its cutting edge and wears very rapidly. Internal stresses also arise in the soft skin which may cause cracking. The stresses can be removed by tempering at 600°.

Influence of inclusions on the polishing of rustless steels. A. M. Portevin and R. Castro. *Iron & Coal Trades Rev.*, **133** [3579] 574 (1936).—A description and compilation of the various types of inclusions that can occur in a rustless steel are given, and their effect on polishing is discussed. Polishing, both industrial and micrographic, depends on the method and type of polishing agent. The reflecting power of the inclusions has some effect on the reflecting power of the steel, dependent on whether the power is about the same, as for sulfides or nitrites, or much lower, as for chromous oxide or silicates. Hardness and brittleness also exert some influence. M.H.

Physical properties of abrasive grain for polishing uses. A. H. Anderson. *Products Finishing*, **1** [10] 20–22 (1937).—While the physical properties of abrasive grain for polishing uses can be measured and are controlled by progressive manufacturers, the user is satisfied only by a performance test. These small grit particles have received much scrutiny and experimentation in recent years with microscopes of high and low power, projectors, capillarity testers, bulking weight machines, impact and abrasion resistance apparatus, briquets, chemical analyses, and screen tests. Abrasive grain shape and size are studied and checked under high magnification. Grain capillarity is an important factor and is, therefore, carefully measured. H.K.R.

Properties of fused alumina grain. A. A. KLEIN. *Metal Ind.* [N. Y.], **35** [8] 401–403 (1937).—The introduction of automatic polishing machines, improvements in abrasive grain, and setting up and drying of the wheels has made possible a set-up in efficiency and improvement in the use of set-up polishing wheels. Chemical composition and crystal structure determine the inherent hardness and strength properties of an abrasive. By far the most important abrasive used in polishing is a fused alumina of approximately the following chemical composition: SiO_2 (silica) 1.50%, Fe_2O_3 (ferric oxide) 0.50%, TiO_2 (titania) 3.0%, and Al_2O_3 (alumina) 95.00% (by difference). *Particle size:* A recent A.S.T.M. symposium agreed that the requirements for particle size of the abrasive industry were so stringent as to place them in a special class. A complete table of the screen specifications meeting these requirements is given. *Capillarity:* Capillarity determines the ease and ability of wetting of abrasive grain surfaces by a glue solution. This property is a function of the cleanliness of grain surfaces. Field experience indicates that a loss of capillarity, due to poor storage conditions, seriously impairs the grip or bonding strength between the glue and the abrasive. *Shape of grain:* Not many years ago the external grain shape was practically uncontrolled and a large variation in grain shape resulted. All requirements are met by two shapes of grain: (1) blocky or chunky, consisting of irregular equidimensional grains as well as thick wedges, and (2) also chunky grain, but having a notable percentage of thinner wedges and flat and elongated grains. For use on sandpaper a third shape composed essentially of thin wedges, flakes, and elongated grain is required. Photomicrographs of grain shapes are given. *Adhesion of grain to glue:* Treating the surface of grain to produce a greater bonding strength between it and the glue has the attention of manufacturers of electric-furnace abrasives. Previously the removal of grease film was accomplished either through a detergent or the volatilization of the film by heat. Grain treated by these methods still finds many very useful applications in polishing, particularly in the finer sizes (No. 100 and finer). To improve the grip of glue on abrasive grain, a chemical heat treatment is given to etch the surface of the grain. The application of different abrasives to various types of work is illustrated by action of two abrasives. See *Ceram. Abs.*, **16** [1] 2; [2] 53 (1937). H.K.R.

Use of abrasives with copper and its alloys. A. CHAPLET. *Cuivre et Laiton*, **9**, 555–61 (Dec. 30, 1936); *Metals & Alloys*, **8** [8] MA495 (1937).—Natural and artificial abrasives, their structural properties, the work for which they are best suited, and necessary equipment are described.

PATENTS

Abrasive article. D. E. WEBSTER (Norton Co.). Can. 367,960, Aug. 10, 1937 (April 20, 1936); see *Ceram. Abs.*, **16** [7] 194 (1937). G.M.H.

Abrasive materials. HANS TIENES. Ger. 629,177, April 24, 1936; Cl. 80*b*. 11; *Chem. Abs.*, **30**, 5012 (1936). Pieces of magnetic iron ore containing FeO 30 to 40, Fe_2O_3 10 to 20, and H_2O about 20%, the remainder being mostly organic matter, are embedded in sand and heated to 1100° to 1300° for 4 to 6 weeks. The product is then ground.

Aluminous abrasive materials. NORTON CO. Ger. 629,087, April 22, 1936; Cl. 12*m*. 6; *Chem. Abs.*, **30**, 5012 (1936). This corresponds to Brit. 350,561 but gives additional details.

Apparatus for forming or dressing grinding wheels. COVENTRY GAUGE & TOOL CO., LTD., H. H. HARLEY, AND J. YORSTON. Brit. 469,876, Aug. 18, 1937(Nov. 29, 1935).

Automatic grinding machine. HARRY ARTER (Arter Grinding Machine Co.). U. S. 2,092,721, Sept. 7, 1937 (March 13, 1936).

Buffing wheel. N. G. SEYBERT (Herman Seybert). U. S. 2,090,814, Aug. 24, 1937 (April 30, 1936). A rotary buffing wheel, comprising a core, and a plurality of radial ropes, some but not all of the strands of the ropes being anchored on the core, whereby there are more strands at the rim than at the core.

Cam grinding machine. C. J. RYBICK. U. S. 2,091,456, Aug. 31, 1937 (Oct. 15, 1936).

Cam lapping machine. H. S. INDGE AND G. E. HULBERT (Norton Co.). U. S. 2,092,734, Sept. 7, 1937 (Aug. 21, 1936).

Centerless grinding machine. ARTHUR SCRIVENER. U. S. 2,091,655, Aug. 31, 1937 (Dec. 30, 1935).

Crankpin grinding machine. H. J. GRIFFING (Norton Co.). U. S. 2,092,732, Sept. 7, 1937 (Aug. 15, 1936).

Flexible abrasives and method of making. THEODOR POHL AND JOSEF SCHNEIDER (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). U. S. 2,091,184, Aug. 24, 1937 (Aug. 8, 1934). A method for preparing flexible abrasives comprises the steps of admixing an abrasive material and a rubber dispersion, adding thereto as additional substances fillers, vulcanizers, and vulcanization accelerators, incorporating therein a gas evolving substance and a decomposition catalyst for catalyzing gas evolution from the gas evolving substance, and securing this mixture to a suitable flexible base material.

Gage for setting internally-threaded blanks in a thread-grinding machine. H. LINDNER. Brit. 470,553, Sept. 1, 1937 (July 16, 1936).

Grinding disk. T. L. F. LARSSON (Norton Co.). U. S. 2,092,978, Sept. 14, 1937 (Dec. 5, 1934).

Grinding machine. N. B. CHACE, JR. (Ray Day Piston Corp.). U. S. 2,091,469, Aug. 31, 1937 (July 28, 1932; renewed Feb. 15, 1937). R. H. CRAMER (General Motors Corp.). U. S. 2,092,876, Sept. 14, 1937 (March 1, 1935). C. C. STEVENS (General Motors Corp.). U. S. 2,092,895, Sept. 14, 1937 (July 3, 1934).

Grinding machine. R. A. COLE (Norton Co.). U. S. 2,092,727, Sept. 7, 1937 (Nov. 25, 1935). A method of determining the size of work pieces circular in cross-section which are being reduced in diameter comprises producing a beam of light, directing the beam of light upon the work piece at such an angle that as the work piece varies in size the axis of the reflected beam moves angularly, and providing a light-sensitive device at a particular point in the locus of the reflected beam as it moves responsive to reduction in diameter of the work piece.

Grinding wheel. NORTON GRINDING WHEEL CO., LTD. (Norton Co.). Brit. 469,993, Aug. 18, 1937 (Jan. 1, 1936).

Grinding wheel. A. T. SOHLSTROM (Norton Co.). U. S. 2,092,591, Sept. 7, 1937 (Aug. 17, 1935). A grinding

wheel comprises a pair of aluminum disks, an annulus of abrasive material surrounding the disks, and a resinoid uniting the disks and the annulus, all parts being permanently and integrally united forming an integral structure thereof.

Grinding wheel truing apparatus. C. G. FLYGARE (Norton Co.). U. S. 2,092,730, Sept. 7, 1937 (Jan. 14, 1936).

Machine for grinding cylindrical bodies. WILLIAM OGILVIE (B. S. A. Tools, Ltd.). U. S. 2,093,363, Sept. 14, 1937 (Dec. 4, 1935).

Machine for grinding twist drills, etc. R. C. WEISHAMPEL (T. J. Galipo). U. S. 20,491, Aug. 31, 1937 (Feb. 2, 1937); reissue of original U. S. 1,989,835, Feb. 5, 1935.

Method of coating abrasive grain. R. C. BENNER AND R. L. MELTON (Carborundum Co.). U. S. 2,092,903, Sept. 14, 1937 (Dec. 16, 1933). The method of producing a film of bonding material on the individual grains of a mass of nonadherent abrasive grains comprises applying a film of solvent containing a synthetic resin bonding material dissolved therein to the grains in mass to form a compact mass of wetted grains, thereafter dispersing the mass of wetted grains in a gaseous medium to individually separate them, and maintaining the dispersion to permit the solvent to evaporate from the individual films while the grains are so separated.

Wheel driving mechanism for grinding machines. C. G. FLYGARE (Norton Co.). U. S. 2,092,714, Sept. 7, 1937 (March 30, 1936).

Art and Archeology

Ceramics in the service of knowledge. ANDRAE. *Ber. Deut. Keram. Ges.*, **17** [12] 623–28 (1936).—It is pointed out how the different cultures of extinct races can be traced through the medium of fragments of ceramic ware they produced. This is possible due to the permanent character of the ceramic ware and the fact that the methods of production and decoration were characteristic for each of the different races. Illustrated. E.J.V.

Method for measuring colors. FUJII KANEKOTO. *Repts. Imp. Ceram. Expt. Inst.* (Tōjikishikensho) *Kyoto*, No. 16, pp. 1–34 (1936); abstracted in *Referat. Silikatliteratur*, **4** [1] 3698 (1937).—With the use of the Young-Helmholtz color theory and the photocell of B. Lange, with three kinds of light filters, K. undertook the measurement of the whiteness, color tone, and brightness of ceramic ware and glass. The apparatus and results obtained are described. See *Ceram. Abs.*, **16** [2] 67 (1937). M.V.C.

Method for studying subjectively color mixtures. V. H. PAVLOVIC. *Compt. Rend.*, **204** [22] 1635–36 (1937).—By combining the Newton color disk with a stroboscopic arrangement a new method was developed to obtain a practically unlimited number of color mixtures on one single disk. The different sectors of the disk are made of colored paper or of colored glasses. The speed of the disk (of 37 cm. diameter) was 1200 r.p.m. By changing the angular velocity of the disk, not only mixtures of two diametrically opposed colors but also mixtures of three or more colors could be obtained. M.H.

Need for art in industry. KENNETH MCCONNEL. *Sydney Morning Herald*, July 29, 1937.—More trained art minds are required in industry. H.H.S.

Physical basis of color measurement. ARTHUR C. HARDY. *Jour. Applied Physics*, **8** [4] 233–39 (1937).—H. reviews the factors to be considered in measurements of color. The basic principles of colorimetry are now established. Future work will be the application of its methods to scientific study and the routine problems of industry. A.P.

Production of crystalline glazes. G. YU. ZHUKOVSKIĬ AND B. V. LYUL'EV. *Keram. & Steklo*, **13** [6] 34–37 (1937).—The following points were determined: (1) Lowering of the SiO_2 content produces an "irregular" crystallization; its increase augments viscosity and therefore lowers the rate of crystallization. (2) Small additions of B_2O_3 lower viscosity; larger amounts of it produce a separation of small crystals with slow cooling; with large additions of B_2O_3 no crystals are formed. (3) Replacement of SiO_2 by boric anhydride lowers the quality of a glaze; because of difficulty in crystallization, no large crystals are present. (4) The replacement of K_2O by alkaline earth metals, in particular CaO, is possible up to 0.15 mol. A further addition increases viscosity and a number of small crystals is formed. (5) Use of alkaline earth metals, in particular CaO, instead of ZnO lowers the crystallization capacity, increases viscosity, and affects the appearance of the glaze. (6) Al_2O_3 increases viscosity and lowers the rate of crystallization. (7) Lowering of the TiO_2 content lowers the crystallization capacity; its increase lowers the rate of crystallization and opacifies the glaze. (8) ZnO added to the basic glaze produces a more intensive reaction (0.1 to 0.2 mol.). (9) PbO in amount of 0.05 to 1.50 mol. has little effect; the adsorption capacity of the crystals is lowered, and the pigment is uniformly distributed in the whole glaze; large quantities of PbO (more than 1.8 mol.) swell the glaze. (10) MgO produces negative results as it lowers the rate of crystallization. The coloring of the glaze is similar to that of ordinary noncrystallizing compounds, with the exception that crystals adsorb the pigments. NiO, 0.5%, produces a greenish blue color in crystals over a light green ground. MnO is not adsorbed, and the crystals and the ware are of a uniform yellow-brown. A mixture of 0.5 Co_2O_3 and 3 to 5% Fe_2O_3 colors the crystals light blue, while the ground becomes light brown. Cr_2O_3 introduced into the frit swells the glaze; when it is introduced into the batch, greenish yellow is obtained. $PbCrO_4$ with CaO colors the crystals into brown-green; the ground is light green. From 0.5 to 1.0% pigment is introduced. When larger amounts are used, the whole piece of ware is uniformly colored and the effect of the crystals is lost. The method used to determine the rate of crystallization, the testing of crystalline glazes, and the firing of the glazes are discussed. M.V.C.

Products of faience and porcelain makers of Andenne. H. JAVAUX. *Verre & Silicates Ind.*, **8** [15] 177–79 (1937).—In 1782 Joseph Wouters introduced the manufacture of faience at Andenne. He made heavy brown or white faience and fine faience of pipe or flint clay. The heavy white faience was not decorated except when covered with a bluish or rose enamel; the pitchers and vessels were covered with a background enamel, usually yellowish

white with floral designs painted by brush in browns, greens, and blues. Small objects and figures were modeled by the French sculptor, Jacques Richardot, affiliated with Wouters; some of these were not coated with enamel because, from an artistic standpoint, the enamel takes away the fineness of the features. Works of Bernard Lammens, successor to Wouters, are much sought after by collectors, *e.g.*, the table services called "The Chateaux," in which a process of black printing was used. Other objects were decorated by a process called "poncif." Polychrome, the rose, the cock, and Chinese decorations were also used. Jacques Fourmy introduced the manufacture of porcelain at Andenne in 1816. He attempted to substitute the plastic clays of Andenne for kaolin in the manufacture of porcelain and made a kind of stoneware called "Hygiocerame." Very little is known of his work. The porcelain factories of Winand and Renard are well known. M.V.C.

Tepe Siyalk pottery. ANON. *Discovery*, **18** [209] 144 (1937).—A prehistoric painted and polished ware of unknown age and cultural affinities has been traced by a French expedition to Tepe Siyalk, near Kashan in central Persia. The British Museum has secured two pots from the mound. H.H.S.

BOOK

Handbook of the pottery and porcelain of the Far East in the Department of Oriental Antiquities. R. L. HOBSON. British Museum, London, 1937. 2d ed. Price 2s 6d. Reviewed in *Times Lit. Supp.*, **36** [1845] 448 (1937). H.H.S.

PATENTS

Ceramic objects. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER (Alwin Hefter, inventor). Ger. 624,947, Jan. 31, 1936; Cl. 80*b*. 23.01; *Chem. Abs.*, **30**, 5010 (1936). The objects are decorated by adding flux mixed with noble metal powder and firing. The flux contains Bi or its compounds in colloidal or soluble form. Thus, rubber resin and Bi resinate are dissolved in turpentine oil and mixed with noble metal powder.

Designs for:

Bottle. A. J. CUNNINGHAM. U. S. 105,751, Aug. 24, 1937 (June 30, 1937). J. H. FUNKEY (Carr-Lowrey Glass Co.). U. S. 105,988, Sept. 7, 1937 (July 22, 1937). W. R. KOHL (Carr-Lowrey Glass Co.). U. S. 105,880, Aug. 31, 1937 (July 10, 1937). W. D. PLUMMER (Owens-Illinois Glass Co.). U. S. 105,969, Sept. 7, 1937 (July 19, 1937).

Goblet. A. J. CUNNINGHAM. U. S. 105,730 to 105,758 and 105,774, Aug. 24, 1937 (June 30, 1937). U. S. 105,759 to 105,762, Aug. 24, 1937 (July 1, 1937).

Plate. FRITZ TEIPELKE (Continental Ceramics Corp.). U. S. 105,783, Aug. 24, 1937 (April 8, 1937).

Tumbler. E. W. FUERST (Libbey Glass Co.). U. S. 105,943, Sept. 7, 1937 (July 10, 1937).

Cements

Components of clinker and their study. H. E. SCHWIETE. *Tonind.-Ztg.*, **61** [28] 309–11; [29] 328–29; [30] 341–44; [31] 353–55 (1937).—S. gives a comprehensive discussion of the constitution of Portland cement, its constituents, and its optical and mineralogical properties. The valuation of the experiments in three- and four-compound systems, the identification of minerals in thin sections and powders with a polarization microscope, the quantitative determination of minerals, the results of X-ray studies, and the valuation of chemical analysis are treated in detail. Illustrated. M.V.C.

Constitution of Portland cement clinker. B. TAVASCI. *Tonind.-Ztg.*, **61** [44] 487–90; [45] 502–504 (1937).—T. gives a table showing the effect of corrosive solutions on various compounds and constituents of clinker. The following compounds react to various corrosive solutions in the same way: tricalcium silicate and alite, dicalcium silicate and belite, tricalcium aluminate and celite-*a*, and the compound $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ and celite-*b*. Without assuming that these constituents are pure (this exists in a certain, although limited, reciprocal solubility), it can be concluded that (1) alite consists of tricalcium silicate. (2) Belite consists of dicalcium silicate in the alpha and beta forms and in an unstable intermediate form (dark needles of belite I) which is comparable to martensite of steel. The alpha form occurs always in the presence of this unstable form. The beta form forms the complete belite of the clinker with sufficiently slow cooling. (3) Celite consists of an intimate mixture of 2 components, one of which (celite-*a*) consists of tricalcium silicate and the other (celite-*b*) consists of the compound $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$. See *Ceram. Abs.*, **14** [4] 87 (1935). M.V.C.

Fused cement: II, Mineral constitution of aluminous cement. KEI-ICHI AKIYAMA. *Jour. Soc. Chem. Ind. Japan*, **40** [4] 139–42B (1937).—The mineral composition of the aluminous cements noted in the first report was calculated with the use of assumptions and compared with the results of microscopic observations. For Part III see *Ceram. Abs.*, **14** [8] 181 (1935). M.V.C.

Hardening problem of silica mortar. V. RODT. *Tonind.-Ztg.*, **61** [33] 210–14 (1937).—The characteristics and behavior of lime silica bonds are discussed on the basis of a series of various studies. These studies are classified into 4 groups: (1) hydrothermal synthesis, (2) synthetic and watery solution, (3) hydration of silicates produced by melting, and (4) hydration of Portland cement. From his own experiments with sand, water-glass, and $CaCl_2$, R. comes to the conclusion that the formation of silicate depends first of all on the formation of an irreversible colloidal silica material which intimately combines with the filling materials into a uniform body and not on the chemical composition of the siliceous bond present in the mortar. The properties and characteristics of blast-furnace cement mortar are discussed in detail. M.V.C.

Influence of magnesia additions on solubility of calcium aluminate slags. G. K. MAGARSCHAK. *Legkie Metally*, **4** [5] 22–27 (1935); *Brit. Chem. Abs.–B*, **56**, 435 (1937).—MgO in amount of 7 to 15% was added to slags containing Al_2O_3 40 to 54, CaO 22 to 48, and SiO_2 7 to 10%. After

crushing, the slags were extracted with aqueous Na_2CO_3 at 75° to 95°. The extraction of Al_2O_3 was ≪ that in slags with no MgO. Mg spinel and melilite were formed.

Progress in the utilization of heat in cement furnaces. F. TURQUAIS. A lecture on "Progress in the Industry of Artificial Portland Cement" held at the Société des Amis de l'École Centrale des Arts et Manufactures, Paris; abstracted in *Ciment*, **40**, 77–83 (1935).—T. summarizes various methods, describing devices to reduce the water content of the aqueous paste and to reduce the heat of the escaping gases from 600°–700°C to 200°–300°C. The following are discussed: recuperating devices, inventions by Leppel of Polysius, of Dessau (Lepol furnace), Andreas process; a device patented to Fellner & Ziegler, evaporating chains inside the furnace, described by Gilbert (*Cement*, January, 1934); external evaporating devices: Polysius evaporator, described by Goebel (*Zement*, Vol. 22, No. 26 (1933)), the Miag calcinator, the Krupp concentrator, the Newman process of utilizing the heat of the clinkers to preheat the air of combustion, etc.

E.St.

Quick-setting and heat-evolving cements: II. KEI-ICHI AKIYAMA. *Jour. Soc. Chem. Ind. Japan*, **40** [5] 167–68B (1937).—Cements whose activity indices are 1.5, 2, and 2.5 (these silica-alumina ratios are generally found in ordinary clay) were studied in order to ascertain whether or not quick-setting and heat-evolving cements can be prepared from ordinary clay and limestone. M.V.C.

Special Portland cements: VI. KEI-ICHI AKIYAMA. *Jour. Soc. Chem. Ind. Japan*, **40** [4] 137–39B (1937).—Tests showed that mangan chrome cement has good strength when it is clinkered at 1450° to 1500°C for a short time. If it is clinkered at higher temperatures than 1500° to 1550°C, its strength may decrease. These properties of mangan chrome Portland cement may be advantageous in large-scale manufacture. For Part V see *Ceram. Abs.*, 15 [9] 267 (1936). M.V.C.

PATENT

Hydraulic gypsum cement material and process of manufacturing. R. S. EDWARDS (Rumford Chemical Works). U. S. 2,090,625, Aug. 24, 1937(May 14, 1936). A method of improving the properties of hydraulic cementitious gypsum materials consists in intimately mixing phosphoric acid and sodium phosphate in an amount not exceeding 2% by weight with hydrated gypsum and dehydrating and calcining the mixture at 1800° to 2300°F.

Enamel

Bathtub enameling. HEINZ KERSTAN. *Glashütte*, **67** [12] 209–11 (1937).—The composition of the iron of the bathtub should be 3.2 to 3.4% C, 2.3 to 2.5% Si, 0.9 to 1.1% P, 0.4 to 0.5% Mn, and 0.05 to 0.08% S. The tub must be sandblasted to remove traces of molding sand and then treated with silicon-carbide abrasives. The wet method is used for the application of the ground coat. The tub must be dried as rapidly as possible to prevent the formation of rust. It is fired in a muffle kiln at 900° to 950°. The application of powder enamel on the red hot tub is accomplished by means of a vibrating sieve under air pressure of 5 to 6 atmospheres. Bathtubs should be cooled slowly to avoid tensions. M.V.C.

Composition, chemistry, and mechanics of drawing compounds. H. A. MONTGOMERY. *Enamelist*, **14** [10] 19–21 (1937).—Drawing compounds, as utilized in the sheet-metal stamping industry, for the most part consist of soapy emulsions containing mildly abrasive pigment materials and generous portions of water, the pigments and water often forming 60 to 75% of the composition. Of the fatty materials used in drawing compounds, palm oil and types of degras seem to possess merit above other types of fats, fatty oils, and greases. Upon saponification they form soaps having definite physical properties in emulsion, two of the principal characteristics being low surface tension and shortness of body. Shortness of body is a combination characteristic of the nature of the fatty substance and the extent of saponification, contributing greatly to the ease of application and removability in subsequent cleaning operations. The high water content of a drawing compound acts as a dispersing medium for a low water-soluble substance, and acts with soapy material in solution as a wetting agent of low surface tension and consequent high activity. Solid materials produce frictional properties and serve to prevent destruction of separating film due to high localized temperature caused by internal molecular movement of metal. Due to the difficulty of cleaning adequately preparatory to subsequent operations, as in the preparation of stampings to be porcelain enameled, use is made of purely soapy materials for drawing compounds to obtain ease of thorough cleaning, though drawing efficiency is somewhat lessened. The development of efficient, easily cleaned drawing compounds is expected soon. E.J.V.

Constitution of bond clays and its influence on bonding properties. R. E. GRIM, R. H. BRAY, AND W. F. BRADLEY. *Trans. Amer. Foundrymen's Assn.*, **7** [5] 211–47 (1936).—The mineral constitution of various clays and its relation to bonding properties are given. The authors make the following conclusions: (1) Clays are composed of one or more groups of minerals which are essentially hydrous aluminum silicates together with alkalis or alkaline earths. (2) The bonding power, durability, etc., of clays vary as the mineral content varies. (3) Clays composed primarily of beidellite ($Al_2O_3 \cdot 3SiO_2 \cdot xH_2O$) or montmorillonite ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O$) have higher green compression strength, higher optimum moisture content, and possibly better durability than those composed of other clay minerals. (4) On the basis of the relation between mineral composition and bonding properties, it is possible to predict the bonding properties of a given clay from its mineral composition as determined by a petrographic analysis. (5) Clays having high base-exchange capacity also have high bonding strength. (6) The physical properties of clays vary, depending on whether sodium, calcium, hydrogen, or some other cation is present as the exchange ion. (7) At elevated temperatures, the clay minerals are transformed to other substances which possess different physical properties. A discussion is included. H.E.S.

Controlled boiling acid test for porcelain enamels. E. E. BRYANT. *Jour. Amer. Ceram. Soc.*, **20** [10] 317–19 (1937).

Developments in porcelain enameling practice. G. P. MacKnight. *Products Finishing*, **1** [11] 16–20 (1937).—More progress has been made in the adaptation and preparation of porcelain enamel finishes in the last few years than during all the centuries in which this flint-hard mineral substance has been used as a finish. New types of porcelain enamels of a highly opaque quality may be applied to the base metal in thinner coats. This effects a saving in that the same degree of coverage can be obtained with much thinner coatings than with the types of enamels heretofore in use. These thinner coatings materially reduce the risk of chipping. Another important step in the preparation of porcelain enamel finishes has been the creation of "clear overglaze" enamels. By their use it is possible to use the ordinary enameling practices and yet obtain an acid-resisting surface by giving a light coat of acid-resisting glaze over the finished article. Illustrated. H.K.R.

Effect of gases from enamels on the heating elements of electric enameling furnaces. F. Arnold. *Elektrowärme*, 7 [7] 145 (1937).—Enamels which have not been fully fused are liable to emit vapors of nitrates, nitrous oxide, carbonates, or fluorides which damage the heating elements and may considerably shorten their life. M.H.

Effect of manganese, nickel, and cobalt oxides upon the adherence and reboiling properties of a ground-coat enamel. E. E. Howe and R. L. Fellows. *Jour. Amer. Ceram. Soc.*, **20** [10] 319–24 (1937).

Enameled copper wire. Electrical Research Assn. *Metal Ind.* [London], **48** [25] 687 (1936).—As a result of recent investigations by the Electrical Research Assn. to determine the effect of voltage on the number of pinholes detected in enameled wire, certain modifications are incorporated in a revised edition of British Standard Specification No. 156. H.E.S.

Enamelled Metal Products Corporation (1933), Ltd. Anon. *Ind. Chemist*, **12** [138] 332 (1936).—An illustration is given of Pfaudler glass-lined equipment showing a complete distillation outfit, so designed that the units, *i.e.*, stills, condensers, receivers, etc., can be connected together into a complete glass-lined system. A cosmetic manufacturing unit, comprising a Pfaudler glass-lined, double-motion, gate-type mixer and glass-lined melting and heating tanks, is also shown. H.E.S.

Factors which affect suspension and consistency of milled enamels. J. E. Hansen. *Enamelist*, **14** [10] 8–13 (1937); *Jour. Can. Ceram. Soc.*, **6**, 69–74 (1937).—Among the factors that may affect the dipping and draining characteristics of milled enamels, H. discusses clays, bentonite, electrolytes, feldspar or quartz, tin oxide or other opacifying agents, the relative "hardness" or "softness" of the water used, the amount of water initially used in the mill charge, variations in the weight of the frit charge or an improper ratio between the frit charge and the grinding balls, temperature during the milling operation, and water content of the milled slips. The problem of restoring set to enamel slips that have lost their best working consistency, by additions of setting-up agents, is discussed. E.J.V.

Metal cleaning: IV, Principles and practice. C. B. F. Young. *Metal Ind.* [N. Y.], **35** [9] 446–50 (1937).—Different methods for cleaning metal prior to plating are described. The conveyer-type continuous washer is discussed. One of the best methods of drying material is by tumbling the work in sawdust. A combination drier and sawdust polisher is described. Cleaning with solvent or degreasing is discussed for both the immersion and vapor methods, together with the necessary stills for recovering material. Illustrated. H.K.R.

Milling porcelain enamel under controlled thermal conditions. O. F. Redd. *Enamelist*, **14** [10] 14–15 (1937).—The control of temperature in the grinding and application of vitreous enamel has become absolutely necessary where modern enamels are used. The higher temperatures during the milling operation increase the solubility of the frit, and this leads to further difficulties in the processing of the ware. In the super-opaque cover-coat enamels now produced, grinding at high temperatures results in lack of gloss and open pitted texture of the fused enamel. With the Cawood process, using a completely jacketed mill, it is possible to grind enamel and apply it at a temperature lower than room temperature. With the cold water circulating through the jacket around the mill, it is possible to use automatic temperature control and maintain a temperature during the milling operation which will have no harmful effect on the enamel being ground. E.J.V.

My fifty years in porcelain enameling. Edward L. Stine. *Enamelist*, **14** [10] 36–38 (1937).—Starting in 1887, when he went to Germany to learn the art of porcelain enameling, S. gives a brief historical sketch of his connection with various porcelain enamel plants producing a variety of ware. He describes the primitive equipment of the German firm, which used halves of large casks for pickle tanks, crushed frit in a chaser mill prior to wet milling, and fired in coal-fired muffles with the fire box at the front. E.J.V.

Outline of interesting enameling problems. J. E. Rosenberg. *Products Finishing*, **1** [10] 5–12 (1937).—R. gives an outline of the major problems of porcelain enameling on which research laboratories have concentrated their efforts: (1) The metal. (2) The glass: Porcelain enamels are glasses of low melting point fixed on cast iron around 1350° and on steel between 1500° and 1600°. Cobalt oxide is most essential in ground coats, for they can be made without the addition of manganese and nickel but they cannot be made without cobalt. (3) Bonding problem: In the case of porcelain enamel, the glass covers the steel, melts, wets it, and then solidifies. (4) Nature of the bond: Photomicrographs of a cross-section of enameled iron show that the bond between the glass and the steel is mechanical and is due to an interlocking of the two materials. The glass in its molten state has penetrated into the iron and is held there mechanically. The glass itself acts as a reagent which digs its own foundation into the iron. Theoretical explanations of the binding action on iron are (*a*) interfacial layer of iron coating glass acting as cement on the nonuniformly etched iron and (*b*) a layer of iron oxide between the metal and the glass. Neither explains the need of cobalt. In the case of enamel on copper, platinum, and gold, the bond seems to be purely adhesion between the glass and the metal, as the metal is wet by the glass. (5) White ground coats: Recently, white enamels uncolored by cobalt, manganese, nickel, or any other color oxides have been developed which adhere

quite well to steel. The bond is of the same general nature as that obtained with cobalt ground coat, a black interfacial layer apparently saturated with iron oxide. The metal is etched, and the glass penetrates in exactly the same way as in the case of cobalt ground coat. This coating eliminates the ground coat, and in one fire a white enamel or any other desired shade may be obtained. (6) Resistance to mechanical shock: Porcelain enamel, being glass, is fragile. The blow necessary to crush glass or porcelain enamel is extremely high, provided the surface is flat or concave and is not distorted by the blow. The proper coefficient of expansion of enamels for stove and refrigerators is discussed. (7) Color: Impurities which can only be detected by the spectroscope are the cause of color difficulties. The physical structure of raw materials must be known and controlled accurately.

H.K.R.

Porcelain enameling. W. J. MISKELLA. *Metal Ind.* [N. Y.], **34** [3] 96–98 (1936).—The details of the use of dry and wet methods are given. The composition of different raw materials and their effect on the characteristics of both kinds of enamel are given with three formulas. A typical steel for enameling purposes is noted. Firing the coatings calls for considerable skill, as the temperature reaches 1800°F. Causes of some difficulties are given. It is noted that the strength of enamels is inversely proportional to the thickness of the coating when properly balanced thicknesses of coating are used. For this reason the heavy coat in the dry process is likely to chip on sharp edges; this difficulty is overcome in the wet process due to the thinner coatings applied. H.K.R.

Settling and antisettling properties of clays. F. H. CLEWS. *Foundry Trade Jour.*, **53**, 422–24 (1935).—C. reviews the works of many investigators on the settling and antisettling properties of clays. Previous work is summarized as follows: (1) The rate of settling of solids in liquids is dependent upon the size of the particles. Particles which are so minute as to settle with extreme slowness are in, or bordering on, the colloidal state. (2) Particles of such size are sensitive to the presence of electrolytes, which can affect the dimensions of the particles and thus their rate of settling. Clays come under this category. (3) The action of electrolytes on clay slips also affects their readiness to flow. (4) In an analogous manner the consistency of enamel slips is related to the effect of electrolytes on the colloidal content of the slip. The clay is probably the most active part of this colloidal fraction. H.E.S.

Stability of solid solutions of ferrous and cobaltous oxides. J. BÉNARD. *Compt. Rend.*, **203** [24] 1356–59 (1936).—The oxides FeO and CoO can be mixed in solid state in any ratio. The decomposition takes place at 570°C according to $4FeO = Fe + Fe_3O_4$ and is reversible at this temperature; at 880°C, this corresponds to the composition 3FeO+CoO. For CoO contents below this formula, the following zones exist: (1) above the equilibrium curve, a region of homogeneous solid solution, (2) between this curve and the horizontal 570°C, a region of cobalt-magnetite and ferrous oxide in excess, and (3) above 570°C, a region of magnetite, Co, and Fe. The conditions are illustrated in a diagram of state of the system FeO–CoO. M.H.

Strength of metals in the light of modern physics. H. J. GOUGH AND W. A. WOOD. *Metal Ind.* [London], **48** [19] 532–36 (1936).—The mechanism of deformation and fracture in metals has been studied from the standpoint of X-ray examination. Whatever type of stressing has been applied (torsion, tension, or compression, static or fatigue) the effect on the structure is one of destruction of the crystals, producing material always in one or more of the following conditions: (*a*) perfect grain, giving a sharp X-ray reflection, (*b*) dislocated grain, giving a reflection which is elongated along the ring, and (*c*) crystallites, very small crystal fragments giving reflections in the form of a sharp line extending farther around the ring than elongation due to dislocated grain. H.E.S.

Town gas for vitreous enameling. W. DIETERICHS AND P. LLOYD. *Foundry Trade Jour.*, **54** [1020] 194–97 (1936).—In the past few years town gas has frequently been adopted for processes previously carried out by means of cheaper fuels, producer gas, coal, or fuel oil. Although the raw fuel costs are higher, the incidental advantages of cleanliness, rigorous control of temperature and furnace atmosphere, and increase in efficiency outweigh the increased fuel costs. Comparative costs of different fuels for frit melting, drying, and firing of the enamels are given. It is pointed out that the potential supplier of town gas is also the purchaser of a great bulk of vitreous enameled ware, *e.g.*, gas cookers, flue material, lighting fittings, etc., hence the dual bond between the consumer and supplier. H.E.S.

Wet-process enamels for cast iron. TOKIJI UCHIDA AND HIDEO SUMIDA. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, **14** [4] 1–108 (1933); *Chem. Abs.*, **30**, 4286 (1936).—The influence of composition, heating temperature, etc., on the quality of the enamels was studied.

PATENTS

Enamel. PORCELAIN ENAMEL & MFG. CO. Ger. 624,803, Jan. 29, 1936; Cl. 48*c*. 5; *Chem. Abs.*, **30**, 5012 (1936). Multicolored fired enamelware is made by spraying coloring oxides and colored enamel on a fusible base such as glaze enamel, fusing, and firing. Thus, Fe ware is coated with a ground enamel of flint, feldspar, borax, $NaNO_3$, Na_2CO_3, fluorspar Co_2O_3, MnO_2, and Al_2O_3 and water. This is sprayed with a colored enamel and then fired.

Enameling iron. IGNAZ KREIDL. Ger. 643,805, April 17, 1937; Cl. 48*c*. 2.02; *Chem. Abs.*, **31**, 5971 (1937). The opaqueness is imparted by gas bubbles without addition of the usual white opaquing agent. A usual enamel mass comprising mostly clay is rendered opaque by a small addition of fine ground KNO_3, which gives off fine O bubbles on heating.

Multicolored enamel. FRANZ NOWAK. Can. 357,573, May 5, 1936; *Chem. Abs.*, **30**, 4291 (1936).—Porcelain-enamel particles are applied to an article base to form a rough surface, coatings of different colors are applied in different directions to the particles, and the article is fired to fuse the enamel particles.

Multicolored enamel. R. H. TURK. Can. 357,581, May 5, 1936; *Chem. Abs.*, **30**, 4292 (1936).—This is similar to the process of the preceding patent except that the article is fired so that it retains its rough surface.

Vitreous enamel organosol. R. S. BLEY (Porcelain Enamel & Mfg. Co.). U. S. 2,090,617, Aug. 24, 1937 (Dec. 31, 1935). An organosol comprises a finely divided vitreous enamel frit uniformly dispersed in a liquid organic silicon compound, the compound being anhydrous and stable at ordinary room temperatures.

Vitreous enamel organosol. R. S. BLEY (Porcelain Enamel & Mfg. Co.). U. S. 2,090,618, Aug. 24, 1937 (Dec. 31, 1935). An organosol comprises a finely divided vitreous enamel frit uniformly dispersed in a liquid organic boron compound, the compound being anhydrous and stable at ordinary room temperatures.

Glass

Applying precision heat to electric lamp manufacture: I. H. K. RICHARDSON AND W. F. WRIGHT. *Ind. Gas*, **15** [5] 14–18 (1936).—Approximately one billion cubic feet of gas is used annually in the production of incandescent lamps and radio tubes. Over 90% of the common lamps are made of soft glass which is worked by air-gas fires. The temperatures in the different operations vary from 300° to 1050°C. Lead glass is worked in a reducing flame, but finished in an oxidizing flame to remove blackening. Various types of gas burners are employed, all producing high-intensity, quiet-burning flames. Burner design is governed by the Passauer formula:

$$\text{Combustion intensity} = \frac{(\text{Cu. ft. of mixture burned/sec.})(\text{net heat value of mixture})}{(\text{area of inner cone of flame})}$$

Piloting is used to prevent flames from blowing off. The two-pipe system of gas and air supply is almost universally used. **II, Gases for glassworking.** *Ibid.*, [6] 21–23.—Natural, manufactured, and mixed gases have all been successfully used in the production of electric lamps. The properties of each are compared, retort and coke oven gas producing the best results. **III, Glassworking.** *Ibid.*, **15** [7] 9–12, 23 (1937).—Due to the great change in viscosity of glass with change of temperature, very close control is required. Variations in pressure, specific gravity, or composition of the gas supplied cause difficulty. The sequence of operations is described. S.S.

Chemical reactions of glass. VIOLET DIMBLEBY. *School Sci. Rev.*, **18**, 330–36 (1937); *Chem. Abs.*, **31**, 2762 (1937).

Composition of glass. G. W. MOREY. *Sci. Monthly*, **42**, 541–54 (1936).—M. shows that, of the whole range of possible silicate compositions, the only mixtures which are fluid enough at an industrially accessible temperature to be melted on a commercial scale, viscous enough to be worked at a temperature above their freezing points, and so viscous at their freezing points that they can not devitrify are those soda-lime-silica glasses in and near the field of the compound $Na_2O{\cdot}3CaO{\cdot}SiO_2$, the compositions which have always been used for commercial glass. This fact was discovered by the Geophysical Laboratory while studying for a number of years the genesis and evolution of rocks formed by the freezing of a molten magma. H.E.S.

Concerning the strength of the weakest bottles. F. W. PRESTON. *Jour. Amer. Ceram. Soc.*, **20** [10] 329–36 (1937).

Conversion of gas-fired tempering furnaces for firing of pots for molten glass to electric firing. H. BILLE. *Elektrowärme*, **7** [7] 143–45 (1937).—An example is described in detail where the economy in heating was considerably improved by abandoning gas in favor of electric firing; heating-up time of the furnaces was reduced from 83 hr. to 53 hr., and two pots could be fired in 3 days against 4 days in gas-fired furnaces. During the 9 months' operation no rejects occurred. The pots were absolutely dense, while in the gas furnaces 4 to 5% of the output had to be rejected on account of cracks. Fine cracks occurred always even in otherwise quite satisfactory pots from the gas furnaces. The electric furnaces could be operated entirely automatically which was not possible with the gas-fired furnaces. M.H.

Corrosion characteristics of SiO_2–Al_2O_3–CaO–MgO glasses. CHARLES F. FRYLING AND FAY V. TOOLEY. *Trans. Illinois State Acad. Sci.*, **29** [2] 92–94 (1936); *Chem. Abs.*, **31**, 3651 (1937).—Fusion in clay pots instead of Pt crucibles, while lacking in accuracy, has the advantage that larger samples can be made and several of them prepared at the same time. Pot corrosion is a function of three related factors: (1) phase equilibrium between batch and pot, (2) change in viscosity of melt due to corrosion, and (3) duration of fusion. Batches containing in excess of 70% $SiO_2 + Al_2O_3$ can be melted in clay pots without excessive corrosion. As the SiO_2-Al_2O_3 content falls below 70%, analytical results become irregular and discordant. Low viscosity in the melt does not necessarily imply high corrosion. If the melt is rich in the ingredients of the materials of the pot, it may be relatively noncorrosive. Dissimilarity in composition and prolonged fusion are always important factors.

Cows and cracks, or measurements of the strength of glassware; their difficulties and meanings. F. W. PRESTON. *Bull. Amer. Ceram. Soc.*, **16** [10] 400–402 (1937).

Dolomite and its use in glassmaking. J. JONES. *Glass*, **14** [5] 184 (1937).—Dolomite can well be used as a glass batch ingredient in soda-lime-silica glasses for it has been found that through the introduction of magnesia, the carbonate of which is a major component of dolomite, the following characteristics are imparted to the glass: (*a*) as magnesia replaces the CaO, within certain limits, in soda-lime-silica glass, the batch is more easily melted; (*b*) MgO introduction, within limits, decreases the setting rate near the working temperature, thus increasing the length of the working range; and (*c*) reduction of the thermal expansion of the glass. M.C.S.

Efficiency of heat-absorbing glasses. W. M. HAMPTON. *Sands, Clays, & Minerals*, **2** [4] 64–71 (1936).—The nature of a heat-absorbing glass as defined either by the efficiency, *i.e.*, the ratio of visible light transmitted to heat transmitted, or by the absorbing power for heat under actual conditions is explained, whereby the ideal glass would transmit the visible light completely, *i.e.*, transmit all wave-lengths from 4000 Å to 7000 Å. The determination

of the efficiency for different glasses is described, taking into account the nature of the glass, especially colored glasses. The action of coloring oxides does not generally change with concentration of the oxide, except with copper oxide; curves are derived to calculate the transmission for any concentration. In the case of rolled plate glass, the heat input into a room through a window is 83% of the total radiation on it, and in the case of a heat-absorbing glass, 38%. Measurements under tropical conditions with 85.5°F shade temperature showed a floor temperature of 135°F with no glass, 124° with ordinary glass, and 98° with heat-absorbing glass. The most effective material so far discovered for absorbing heat in glass without serious reduction in the light transmission is ferrous iron. See "Physical—," *Ceram. Abs.*, **14** [10] 245 (1935). M.H.

Egyptian glass of B. C. 2000. HJALMAR LARSEN. *Discovery*, **18** [210] 187 (1937).—At Abu Ghalib, a Swedish expedition has discovered Egyptian glass manufactured 500 years earlier than it was believed to exist. H.H.S.

Electric melting of glass. ANDERS STRELING-CORNELIUS. *Industritidning. Norden*, **63**, 80–82 (1935); *Chem. Abs.*, **31**, 2761 (1937).—An illustrated review is given.

Electrical conductivity of thin metallic films: I, Rubidium on Pyrex brand glass surfaces. A. C. B. LOVELL. *Proc. Roy. Soc.* [London], **A157**, 311–30 (1936).—Measurements of the resistivity of thin films of rubidium deposited on cooled Pyrex surfaces by a defined atomic beam are described. Conductivity has been observed with films only 1 Å thick. Normally, the films showed a decay of conductivity with time, but this decay decreased with increasing film thickness and with a lowering of the temperature of deposition. The thickest film investigated (90 Å) was still invisible but obeyed Ohm's law up to current densities of at least 10^8 amp./cm.^{2} The variation of resistivity with thickness and temperature for these stable films is in quantitative agreement with a formula derived by simple quantum mechanical treatment. The phenomenon of the decay of conductivity is discussed in terms of a break up of the film under surface-tension forces.

A.P.

Fused silica in heating processes: III, Heaters and radiants. B. MOORE AND R. BROWN. *Ind. Chemist*, **12** [143] 561–64 (1936).—The application of fused silica as electrical insulators, tubes, holders, radiants, dishes, and hot plates in the following heating units is described: (1) *Electrical heaters:* (*a*) immersion heaters, where the unit is required for heating liquids, *e.g.*, acid liquors, boiler water, etc., and is immersed in liquid; (*b*) room and office heaters, in which the unit is exposed, preferably in front of a suitably shaped reflector; and (*c*) heaters for apparatus, where the unit may be complete in itself and can be used under apparatus containing materials to be heated or may provide the heating element only of a furnace or heating chamber. (2) *Gas heaters:* (*a*) room and office heaters, where a gas-heated element is exposed; and (*b*) heaters for apparatus, which include induced and forced-draft burners. Illustrated. For Part II see *Ceram. Abs.*, **16** [10] 309 (1937).

H.E.S.

Glass for modern electric lamps. J. SMELT. *Phillips Tech. Rev.*, **2** [3] 87–93 (1937); *Glass*, **14** [7] 280–84, 293 (1937).—Glass is defined technically as a transparent solid material made from very cheap raw materials, such as sand, soda, lime, etc., highly resistant to chemical attack, which in the fluid or viscous state can be worked to any desirable shape, and physically as a super-cooled liquid, *viz.*, a solution of silicates in silicic acid. This simple description does not entirely agree with the facts, for various properties of glass, such as the viscosity, the thermal expansion, and the electrical resistance, exhibit anomalies between 500° and 600°C. This temperature, specific for each kind of glass, is termed the normalizing temperature. All worked glass must be reheated to these temperatures in order to avoid mechanical stresses which cause the glass to crack on cooling. The use of a wide range of new constituents of glass has enabled a large number of new glasses to be produced possessing specific optical, thermal, chemical, and electrical properties. The electric-lamp manufacturing industry has gained much from the advances made in glass physics and technology. In addition to a comprehensive knowledge of the properties of glass in the vitrified and viscous states (the rate of fusing the flanged stem tube to the lamp bulb is determined by the velocity with which the bulb can be heated without cracking and by the time taken by the various components to fuse together), the electric-lamp industry also requires a variety of glasses possessing different properties. Electric lamps, radio receiving valves, X-ray tubes, mercury, sodium, and neon lamps all require their own type of glass with well-defined properties. In electric-lamp manufacture, the mechanical processes entailed require the glass to be easy and rapid to melt and shape. The use of these products in the tropics necessitates a marked chemical resistance to moist heat. The action of sodium and mercury at high temperatures must not cause a deterioration of the glass used for these lamps. In view of the need for adequate insulation against high electric tensions, frequently at a distance of only a few millimeters, the electrical resistance has to meet strict specifications. The effect of various materials in obtaining these requirements is discussed. The causes and cure of weathering of bulbs are discussed. Simple means have been devised to raise the resistance of the glass against atmospheric influences, *viz.*, heat treatment of the bulb in an atmosphere of sulfur dioxide. While glass is one of the best electrical insulating materials, its electrical resistance, W, varies with the temperature according to the equation $\log W = B/T + A$, where A and B are constant for a specific composition. This equation is valid up to the normalizing temperature. Above this temperature, the same relationship applies with different values for A and B. Conduction in glass is electrolytic, the current being carried by the alkalis and mainly by the Na ions. In radio valves and d.-c. electric lamps so-called "lead trees" (illustrated) sometimes make their appearance at the negative pole after long use, together with fine cracks at the positive pole. This phenomenon is obtained irrespective of the material of which the leading-in wire is made, whether of platinum, nickel-iron or chrome-iron wire, or dumet wire. If, in a particular lead glass, Na_2O is replaced by K_2O or/and the PbO content is raised, a series of glasses is obtained with a considerably high resistance and hence less liable to form lead trees or to crack. Opal glasses, colored glass for photographic or illumination

purposes, and hard glass bulbs are made for special purposes. Present day gas-discharge lamps and tubes with their multitude of designs and types have introduced a series of new problems and requirements such as the effect of mercury and sodium on glass. Transmission factor of glass for different wave-lengths, especially in the visible spectrum and in the ultra-violet region, is of importance. Quartz transmits the whole of the ultra-violet to 1850 Å. The effects of composition on these factors are given in detail. Every subsequent operation to which the glass must be submitted is so difficult and tedious owing to the material's great hardness and brittleness that it is advisable in making all glass objects to use only such designs in which the internal diameter can vary between wide limits. If the cavity is low and so shaped that it can be readily removed from a shaped die, the shaping process can also be performed by pressing, when an exceptionally high standard of accuracy can be achieved. The use of coated bulbs for inhibiting sodium attack is discussed. The necessity of designing bulb shapes to facilitate blowing is mentioned. Illustrated. H.K.R.

Glass-silvering solutions: II. K. NAKANISHI. *Jour. Japan. Ceram. Assn.*, **42**, 127–36 (1934); *Jour. Soc. Glass Tech.*, **19**, A74 (1935).—Excess of NH_3 prevented deposition of silver in the Rochelle-salt process. Below 0.0014 g. of $AgNO_3$ per sq. cm. of glass surface, it was impossible to obtain a good mirror, but otherwise similar results were given by a solution of low Ag content with one of high Rochelle-salt content and by one of high Ag content with one of low Rochelle-salt content. Addition of $AgNO_3$ to the Rochelle-salt solution and boiling for an hour gave a solution of increased reducing power. This effect was not due to Ag ion, colloidal Ag, NO_3, or the acidity of the solution. For Part I see *Ceram. Abs.*, **16** [4] 114 (1937).

Homogenizing process in glass melts. HANS JEBSEN-MARWEDEL. *Angew. Chem.*, **50**, 400–406 (1937); *Chem. Abs.*, **31**, 5963 (1937).—The course of the homogenizing diffusion is determined by the formation of honeycombs, gas separation, deformation, and surface tension. Photographs of the melting process, streak formation by gas bubbles, and surface tension differences are presented. A mathematical discussion is included. Nine references.

House with glass walls. S. HENRY KAHN. *Master Builder*, **42** [896] 186–87 (1937).—A solution of the problem of obtaining sufficient light in a house situated on a small piece of ground in which the possibilities of lighting are limited is suggested by a building recently completed in Brussels by Paul A. Michel; the front and rear walls are of glass, the side walls along the property lines are of ordinary brick construction, and the frame and floors are concrete. Further details are given. M.V.C.

Manufacture of glass. M. PARKIN. *School Sci. Rev.*, **17**, 501–509 (1936); *Chem. Abs.*, **30**, 5007 (1936).

Manufacture of optical glasses: I. TÔRU TAKAMATSU. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, **16** [11] 1–41 (1936); *Chem. Abs.*, **30**, 5378 (1936).—A general discussion and detailed directions for the manufacture of good optical glasses are given.

Manufacturing glass absorbing X-rays. V. I. VANIN. *Keram. & Steklo*, **13** [4–5] 35–37 (1937).—The thickness of glasses used for protection from X-rays is limited by the so-called lead equivalent, alpha, which represents the thickness of lead of the protective layer of the glass. The ratio of the lead equivalent to the thickness of the glass is called Pb coefficient, which varies, depending on the content of PbO and other oxides and the thickness of the glass. The glass manufactured was of the following composition: 35.88 SiO_2, 50.79 PbO, 6.86 $Na_2O + K_2O$, 3.54 Al_2O_3, 0.11 Fe_2O_3, 0.14 MgO, 0.98 F_2, and 0.84 SO_3. Lead equivalents may be determined again by means of (1) photographic method, (2) monometric method, and (3) measuring the index of refraction of the glass provided that the dependence between the Pb equivalent and the index has been determined. M.V.C.

Newest in eyeglasses. W. KAEMPFFERT. *N. Y. Times*, Aug. 22, 1937.—Contact lenses slip under the lids and rest over the eyeball. A mold is made of the eyeball with a mixture of negocoll and water. This is cast in plaster from which Carl Zeiss makes the contact lens. Much delicate grinding is required for a perfect fit. The lenses take about 2 months to make and may cost as much as $150. M.V.C.

Pot furnace of the Semionov type. A. P. NIKITIN. *Keram. & Steklo*, **13** [4–5] 37 (1937).—N. briefly reviews the characteristics of a new pot furnace for melting special glass (optical, technical, etc.). M.V.C.

Quantitative glass-strain analyzer. C. F. BALDWIN. *Gen. Elec. Rev.*, **40** [7] 319–20 (1937).—A device has been developed for the purpose of inspecting glass-to-metal seals and other cylindrical glass pieces. This glass-strain analyzer, which gives qualitative and quantitative indications of strains in glass, consists primarily of two elements, designated as the polarizer and the compensator. The polarizer is a light-polarizing element which differs from the conventional Nicol prism in that it is of the more recently developed thin-film type. The compensator consists of a similar second film so rotated with respect to the first as to give the crossed Nicol extinction effect and a system of thin crystalline quartz wedges so cut and arranged that their optical axes are at right angles to each other. L.E.T.

Relation which exists between the transformation temperature and the change of the index for several kinds of glasses. NIUTA WINTER-KLEIN. *Compt. Rend.*, **204** [20] 1470–72 (1937).—By using the change of refractive index as a characteristic for the change in physical properties of glasses when cooled down from different temperatures, a study was made to determine the properties from the curve of the refractive index, or *vice versa*. A relation exists between the maximum variation of the index and the temperature at which the glass is transformed from the α to the β modification; the higher the transformation temperature the greater is the variation of the index, the curve for which is shown. The curve can be used to determine whether a glass has been sufficiently annealed for a given purpose. Five references. M.H.

Rotosil, the new nontransparent quartz glass. HERAUS QUARZGLAS-G.M.B.H. *Eng. Progress*, **18** [6] 136 (1937).—Pure quartz sand is formed into a tube in a centrifugal mold. The tube is internally fused to produce a smooth, nonporous quartz layer on the inside. Implements of Rotosil will stand 1200°C and are not affected by heat shock. They also resist all acids except HF. They can readily be sealed to transparent fused quartz glass. A

thickness of 1 mm. starts to break down only under a difference of potential of 20,000 volts. J.L.G.

Safety glass. F. H. ZSCHACKE. *Gelatine, Leim, Klebstoffe*, **5**, 48–56 (1937); *Chem. Abs.*, **31**, 5964 (1937).—*Z.* reviews the development, present methods of production, methods of testing, and approximate standards required for safety glass. See *Ceram. Abs.*, **15** [11] 332 (1936).

Series of glasses colored by sulfurous matter: IV, Colored glasses with sulfur and carbon. K. FUWA. *Jour. Soc. Chem. Ind. Japan*, **40** [5] 169–70B (1937).—The results of experiments show that the differing color intensity of the glasses is observed in accordance with the variation of the amount of carbon even if the amount of sulfur added to the batch is kept constant. In general the yellowish brown sulfide color of the glass is due to the polysulfide contained in it. For Parts **II–III** see *Ceram. Abs.*, **16** [8] 241 (1937). M.V.C.

Silicates in television apparatus. ANON. *Discovery*, **18** [208] 126 (1937).—Luminescent Zn orthosilicate to be used in television screens is being made in Russia by triturating ZnO and SiO_2 in the presence of an activator (a Mn salt) and calcining the mixture at 1200°C. Success depends upon the use of extremely pure materials, the "chemically pure" materials of commerce being unsatisfactory. The proportion of Mn in the final product should be 1%. H.H.S.

Surface tension of various molten glasses. A. E. BADGER, C. W. PARMELEE, AND A. E. WILLIAMS. *Jour. Amer. Ceram. Soc.*, **20** [10] 325–29 (1937).

Transformation points of glasses. P. BARY AND J. HERBERT. *Compt. Rend.*, **204** [24] 1809–11 (1937).—The fusion of vitreous substances is not a continuous process but presents two transformation points: one where the substance begins to become deformable under pressure, at temperature T_1, and another at T_2, usually between 500° and 1400°C. These two temperatures are connected by a relation which can be expressed by $\log(10^{13}/\mu) = A \log(T_1/T_2)$, where A is $[\log(10^{13}/\mu_2)] \;/\; [\log(T_2/T_1)]$ and μ is the viscosity in poises. A few examples are given. M.H.

Unlike valence of lime raw materials in glass industry. E. O. SCHULZ. *Glashütte*, **67** [12] 205–206 (1937).—S. discusses several cases from practice where the lime raw materials used in glassmelting affected the glass because of their unlike properties and composition. M.V.C.

BOOKS

Hardened Glasses. CORRADO ROVINI. U. Giardini, Pisa. 60 pp. Price 10 L. Reviewed in *Verre & Silicates Ind.*, **8** [21] 252–53 (1937).—In this symposium of hardened safety glasses, R. defines hardening and its characteristics, annealing, and measurement of tension by accidental refraction. The analytical graphic calculation of tensions of hardened glass and the influence of the thickness, manufacture and equipment, and tests and numerical results obtained on hardened glasses of Italian manufacture are discussed. M.V.C.

Manufacture of Optical Glass in Italy. CORRADO ROVINI. Price 35 L. Reviewed in *Verre & Silicates Ind.*, **8** [21] 252 (1937).—This volume is the first of a collection published under the auspices of the Fascist Federation of Glass Industries. R. has treated his subject from a scientific, technical, and economic point of view. The history of optical glass since Alexander della Spina, who died at Pisa about 1313, is a most interesting chapter. The work of Galileo, Guinand, Abbe, Bontemps, Schott, and contemporaries is analyzed in detail. The manufacture and properties of optical glasses are handled in the most modern scientific manner. Numerous illustrations of furnaces, crucibles, and technical processes are given. The last chapters are devoted to specifically Italian conditions, *e.g.*, incidence of optical glass in national commerce, work of laboratories, the factory at Murano, deposits of raw materials in Italy, and scientific organization. M.V.C.

Translucid Concrete (Le Beton Translucid). POLIVKA-JAROSLAV. Les Études des Composés Siliceux, Brussels, 1937. Monograph II. 119 pp. 95 figs. Price 40 F. Illustrations show the varied uses to which "glass-crete" can be put and some modern buildings in which glass and reinforced concrete have been combined to give beauty, light, and strength. M.V.C.

PATENTS

Annealing apparatus for drawn glass. PILKINGTON BROS., LTD., AND J. GASKELL. Brit. 469,668, Aug. 11, 1937 (Jan. 29, 1936).

Annealing furnace for glassware. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 643,562, April 12, 1937; Cl. 23*a*. 29; *Chem. Abs.*, **31**, 5967 (1937).

Apparatus for:

Cooling large masses of molten glass. CORNING GLASS WORKS. Fr. 795,051, March 3, 1936; *Chem. Abs.*, **30**, 5381 (1936).

Drawing and cutting glass tubing. COMPAGNIE DES LAMPES. Fr. 791,462, Dec. 11, 1935; *Chem. Abs.*, **30**, 4288 (1936).

Heating sheets of glass for tempering. AMERICAN SECURIT CO. Fr. 794,398, Feb. 14, 1936; *Chem. Abs.*, **30**, 4640 (1936).

Making colored glass by adding a coloring constituent to a stream of fused colorless glass. SOC. ANON. HOLBREVER. Ger. 627,217, March 12, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 4288 (1936).

Making fibers of glass and similar fusible materials. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 624,586, Jan. 24, 1936; Cl. 32*a*. 25; *Chem. Abs* **30**, 5009 (1936). Addition to 615,804 (*Ceram. Abs.*, **15** [8] 240 (1936)).

Manufacture of laminated glass. F. L. BISHOP, C. S. SHOEMAKER, C.F.WOOD, EDLO DONNINI, AND L.J. PIERCE (American Window Glass Co.). Can. 358,126, May 26, 1936; *Chem. Abs.*, **30**, 5010 (1936).—Glass sheets coated with strengthening material are dried, and the solvent is removed by placing the sheets horizontally in a heated chamber on a conveyer, supplying air to the chamber above the conveyer, and removing the air and gas from below the conveyer.

Manufacture of laminated glass. EDLO DONNINI (American Window Glass Co.). Can. 358,124, May 26, 1936; *Chem. Abs.*, **30**, 5010 (1936).—A roll operates in a liquid reservoir to form a film of strengthening material on the roll. An adjacent roll transfers the film from the first roll and delivers it down an inclined heated plate onto a glass sheet.

Mechanically transferring bottles or other glassware. T. F. PEARSON. Brit. 469,912, Aug. 18, 1937 (Feb. 7, 1936).

Polishing traveling flat glass. PILKINGTON BROS., LTD., AND J. H. GRIFFIN. Brit. 469,951, Aug. 18, 1937 (Feb. 5, 1936).

Tempering glass objects. PILKINGTON BROS., LTD. Fr. 792,280, Dec. 26, 1935; *Chem. Abs.*, **30**, 4289 (1936).

Articles containing vitreous silica. J. F. HYDE (Corning Glass Works). Can. 357,430, April 28, 1936; Fr. 792,923, Jan. 13, 1936; *Chem. Abs.*, **30**, 4289 (1936). A hydrolyzable compound of Si is vaporized into a high-temperature flame of combustible gas combined with O. The flame is impinged on a refractory core to deposit a layer containing at least 99.999% of SiO_2, which is vitrified as fast as it is deposited by the flame at 1200° to 1400°.

Blowing hollow glass bodies. VERRERIES-GOBELETERIES L'ESPÉRANCE SOC. ANON. Ger. 642,905 and 642,906, March 20, 1937; Cl. 32*a*. 8; *Chem. Abs.*, **31**, 5966 (1937).

Conveying glass sheets to leer. GLACERIES DE LA SAMBRE, S. A. Ger. 639,767, Nov. 26, 1936 (May 30, 1934); G 90,256, VI/32*a*, Gp. 34; *Jour. Soc. Glass Tech.*, **21** [85] A191 (1937). Between the rollers of a conveyer for moving glass sheets into a leer set at right angles to the direction of the conveyer there are set bearer members movable in the direction of the leer, their upper surfaces consisting of small strips arranged parallel to each other and as far apart as possible.

Cutting up vertically drawn sheet glass. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Ger. 640,447, Dec. 10, 1936(Aug. 14, 1934); N 37,054, VI/32*a*, Gp. 33; *Jour. Soc. Glass Tech.*, **21** [85] A191 (1937). In a process of the above type in which the sheet is severed by a cutting tool moved across it, a straight-edge serves as guide for the cutting tool and a similar straight-edge engages the glass on either side over its whole width in correct relation for making the cut and supporting the glass.

Decolorizing glass. ALFRED THÜRMER AND WALTER KERSTAN. Ger. 645,048, May 20, 1937; Cl. 32*b*. 2; *Chem. Abs.*, **31**, 5966 (1937). Coloration of glass by Fe compounds is avoided by adding NaF to the melt with or without an oxidizing agent, *e.g.*, MnO_2, $NaNO_3$, or a chlorate or perchlorate. A typical melt is made from sand 50, CaO 15, soda 25, NaF 1.5, and $NaNO_3$ 0.5 parts.

Device for molding the mouths of glass flasks. EMMY BORNKESSEL (*née* Bachmann). Ger. 623,932, Jan. 8, 1936; Cl. 32*a*. 26; *Chem. Abs.*, **30**, 5009 (1936).

Drawing out sheets of glass. OXELÖSUNDS JÄRNVERKS AKTIEBOLAG (G. Norvásky, inventor). Swed. 84,847, Nov. 12, 1935; *Chem. Abs.*, **30**, 6522 (1936). In a process wherein glass is melted and drawn out through slotted orifices, the nozzle piece, during the melting, is kept immersed below the surface of the glass, *e.g.*, by means of air-cooled steel tubes. Apparatus is described.

Electric furnace for glass, etc. YNGVE R. CORNELIUS. Fr. 804,356, Oct. 22, 1936; *Chem. Abs.*, **31**, 3656 (1937). Means to maintain the fusion zone at uniform temperature and disposition of electrodes are described.

Forming necks on vessels made from tubing. J. DICHTER. Ger. 639,444, Nov. 19, 1936 (Aug. 10, 1934). Addition to 605,837, D 68,564, VI/32*a*, Gp. 27 (*Ceram. Abs.*, **14** [7] 163 (1935)); *Jour. Soc. Glass Tech.*, **21** [85] A190 (1937). In a process according to the parent specification, the neck is formed first by heating only the portion corresponding to the neck, and then the end portion adjacent is heated and drawn out to a point.

Furnace for fusing quartz. I. G. FARBENIND. A.-G. Fr. 791,666, Dec. 14, 1935; *Chem. Abs.*, **30**, 4290 (1936). Above a movable hearth is fixed a cylindrical brick-lined vessel the height of which is greater than the internal diameter and on which is a dome-shaped roof with access means for the heating gases.

Fused silica and silica glass. CORNING GLASS WORKS. Fr. 805,007, Nov. 9, 1936; *Chem. Abs.*, **31**, 3656 (1937). Fused SiO_2 and SiO_2 glass are obtained free from bubbles by melting the material in the presence of He, so that the bubbles in the mass contain practically pure He instead of air or other gases, and maintaining the mass fused until the He has diffused out.

Glass. CORNING GLASS WORKS. Ger. 645,460, June 1, 1937; Cl. 32*b*. 2; *Chem. Abs.*, **31**, 5966 (1937).

Glass. PILKINGTON BROS., LTD. Fr. 794,107, Feb. 8, 1936; *Chem. Abs.*, **30**, 4639 (1936). Apparatus for indicating and regulating the level of the glass in the reservoir is described.

Glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 792,996, Jan. 14, 1936; *Chem. Abs.*, **30**, 4288 (1936). Means is described for securing homogeneity of the glass in the furnace.

Glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 793,942, Feb. 4, 1936; *Chem. Abs.*, **30**, 4639 (1936). The construction of rollers for carrying hot sheets of glass is described.

Glass article tempering method. B. LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). Can. 367,633, July 27, 1937 (April 6, 1936). G.M.H.

Glass-blowing machine. EUROPÄISCHER VERBAND DER FLASCHENFABRIKEN G.M.B.H. Ger. 641,800, Feb. 17, 1937; Cl. 32*a*. 15; *Chem. Abs.*, **31**, 5966 (1937).

Glass building blocks and method of making. D. E. GRAY (Corning Glass Works). U. S. 2,091,504, Aug. 31, 1937 (May 21, 1934; March 7, 1935).

Glass composition. S. R. SCHOLES (Celo Mines, Inc.). U. S. 2,091,691, Aug. 31, 1937 (Oct. 23, 1935). The method of making homogeneous commercial glass containing alumina and capable of being fashioned into glassware comprises the step of introducing into the melt as a batch ingredient kyanite in a finely granular condition such as will pass through a 20-mesh up to a 60-mesh screen.

Glass cooling and tempering apparatus. GASTON DELPECH (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). Can. 367,634, July 27, 1937 (July 6, 1936). G.M.H.

Glass cutting apparatus. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,091,332, Aug. 31, 1937 (June 23, 1936).

Glass cutting shears. F. C. LINK AND S. G. STUCKEY (Obear-Nester Glass Co.). U. S. 2,092,650, Sept. 7, 1937 (Aug. 1, 1935).

Glass feeding apparatus. T. F. PEARSON (Crown Cork

& Seal Co., Inc.). Can. 368,118, Aug. 17, 1937 (Sept. 15, 1936). G.M.H.

Glass insulated underground electric cable. H. M. HOBART (General Electric Co.). U. S. 2,092,647, Sept. 7, 1937 (Aug. 24, 1935).

Glass molding machine. J. W. ERRETT (Capstan Glass Co.). Can. 368,237, Aug. 24, 1937 (April 7, 1936; in U. S., July 8, 1935). G.M.H.

Glass plate tempering furnace. L. J. FORBES (Pilkington Bros., Ltd.). Can. 367,625, July 27, 1937 (Feb. 6, 1936). G.M.H.

Glass resistant to hot alkali-metal vapor. LOUIS NAVIAS (Canadian General Electric Co., Ltd.). Can. 367,567, July 27, 1937 (May 16, 1935). G.M.H.

Glass rod or tubing drawing and severing apparatus. C. A. BROWN AND F. B. VAN SICKLE (Canadian General Electric Co., Ltd.). Can. 368,203, Aug. 24, 1937 (April 18, 1935). G.M.H.

Glass sheet tempering apparatus. J. M. D. DE TAILLY (Soc Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). Can. 367,787, Aug. 3, 1937 (April 15, 1936). G.M.H.

Glass tank furnace and process of putting into use. CORHART REFRACTORIES CO. Brit. 469,723, Aug. 11, 1937(March 25, 1936).

Glass tempering apparatus. W. B. CLITHEROW (Pilkington Bros., Ltd.). Can. 367,626, July 27, 1937 (Aug. 26, 1936). ANDRE DO-HUU-CHAN (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Can. 367,788, Aug. 3, 1937 (Aug. 27, 1936). L. J. FORBES (Pilkington Bros., Ltd.). Can. 367,627, July 27, 1937 (Aug. 28, 1936). Can. 368,140, Aug. 17, 1937 (May 22, 1936). BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). Can. 368,258, Aug. 24, 1937 (April 2, 1936). WILLIAM OWEN (American Securit Co.). Can. 367,741, Aug. 3, 1937 (Aug. 5, 1936). G.M.H.

Glass treatment. E. D. TILLYER (American Optical Co.). U. S. 2,092,789, Sept. 14, 1937 (Sept. 13, 1934).

Glass vessel producing apparatus. JAKOB DICHTER. Can. 368,009, Aug. 10, 1937 (April 20, 1936). G.M.H.

Glassware annealing apparatus. D. G. MERRILL (Hartford-Empire Co.). Can. 367,940 to 367,942, Aug. 10, 1937 (Nov. 3, 1936). G.M.H.

Glassworking apparatus. H. R. SCHUTZ (Libby Glass Co.). Can. 367,775, Aug. 3, 1937 (Dec. 30, 1935). G.M.H.

Glassworking machine. H. H. SNYDER (Corning Glass Works). U. S. 2,091,494, Aug. 31, 1937 (May 23, 1936).

Hardened glass and method of making. FRITZ ECKERT (American Securit Co.). U. S. 2,093,040, Sept. 14, 1937 (July 26, 1935). The method of hardening glass to develop permanent stresses therein and to minimize the development of temporary stresses consists in heating the glass to approximately its softening point, rapidly chilling the glass from approximately its softening point down to a temperature approximately that of its lower annealing temperature, and cooling the glass at a slower rate.

Installation for the manufacture of glass sheets, particularly of colored glass, and of opaque glass, colored or not. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Brit. 469,962, Aug. 18, 1937 (June 13, 1935).

Laminated glass. F. L. BISHOP, R. H. DUBOIS, AND PATRICK FINNEGAN (American Window Glass Co.). Can. 358,123, May 26, 1936; *Chem. Abs.*, **30**, 5010 (1936).—A film of a solution of strengthening material and a solvent is flowed over an inclined plate, and a glass sheet is conveyed past the lower edge of the plate which pulls the film off the plate onto the glass. The film is dried, and the glass sheets are rigidly united. An apparatus is described.

Laminated glass. C. S. SHOEMAKER (American Window Glass Co.). Can. 358,125, May 26, 1936; *Chem. Abs.*, **30**, 5010 (1936).—A coating of a strengthening material, *e.g.*, an acrylic acid ester with a solvent such as dibutyl phthalate, is formed on a glass sheet and dried by passing air vertically downward along the edges of the sheet. The temperature of the air is below the boiling point of the solution at first and then gradually raised to above the boiling point, while pressure adjacent to the coating is maintained lower than atmosphere pressure. An apparatus is described.

Leer stacking or feeding mechanisms. E. P. DORMAN (United Glass Bottle Manufacturers, Ltd.). Can. 358,185, May 26, 1936; *Chem. Abs.*, **30**, 5009 (1936).—Glassware is conveyed transversely across a leer entrance and a stacker bar operates at regular intervals across the conveyer to sweep the ware into the leer. All the movements of the conveyers and stacker bar are operated at related speeds in synchronism with the glass-forming machine and from a common source of power.

Light-diffusing glass. MACBETH-EVANS GLASS CO. Ger. 622,600, Dec. 2, 1935; Cl. 32*b*. 5; *Chem. Abs.*, **30**, 5012 (1936). A pearling agent is dissolved in clear glass, and part of this glass, after being formed into a globe or shade, is rendered opaque by heating.

Machine for making glass vessels. CARR-LOWREY GLASS CO. Ger. 624,787, Jan. 28, 1936; Cl. 32*a*. 15; *Chem. Abs.*, **30**, 5009 (1936).

Machine for shaping the ends of glass receptacles and tubes. J. DICHTER. Brit. 469,585, Aug. 11, 1937 (Dec. 11, 1935).

Manufacture of multicellular glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 455,594, Nov. 4, 1936 (June 5, 1935).

Means for charging glassmelting furnaces. HARTFORD-EMPIRE CO. Ger. 627,216, March 11, 1936; Cl. 32*a*. 5; *Chem. Abs.*, **30**, 5008 (1936). See Brit. 419,681(*Ceram. Abs.*, **14** [3] 69 (1935)).

Mechanism for severing molten glass. F. L. O. WADSWORTH (Ball Bros. Co.). U. S. 2,093,375, Sept. 14, 1937 (Jan. 23, 1933; renewed May 21, 1937).

Method and apparatus for feeding molten glass. F. L. O. WADSWORTH (Ball Bros. Co.). U. S. 2,093,373, Sept. 14, 1937 (Jan. 23, 1933). U. S. 2,093,374, Sept. 14, 1937 (Feb. 18, 1933).

Method and apparatus for manufacturing mats or layers from glass fibers and other inorganic fibrous material. N. V. MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 470,675, Sept. 1, 1937 (Oct. 1, 1935).

Method of manufacturing glass bottles. D. D. GORDON

(Dominion Glass Co., Ltd.). U. S. 2,091,238, Aug. 24, 1937 (Dec. 16, 1935).

Ornamenting glassware. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M.B.H. (Adolf Fehse and Artur Ewald, inventors). Ger. 645,392, May 26, 1937; Cl. 32*b*. 7; *Chem. Abs.*, **31**, 5967 (1937).—A description is given of an apparatus whereby minute mechanical abrasions are produced on hollow glassware at a number of points arranged to form a design.

Photoluminescent glass. I. G. FARBENIND. A.-G. Fr. 792,844, Jan. 11, 1936; *Chem. Abs.*, **30**, 4288 (1936).—An excitable metal, *e.g.*, a heavy metal, is added to a phosphate glass of which at least 20% of the acid constituents consists of P_2O_5. The glass is melted under reducing conditions. Thus, to a glass containing H_3PO_4 (specific weight 1.75) 1000, $BaCO_3$ 175, Al_2O_3 70, and MgO 55 parts is added Cu oxide 10 and sugar 25 parts. The mass is made vitreous and formed to the desired shape.

Plating by thermal evaporation. R. C. WILLIAMS. U. S. 2,079,784, May 11, 1937 (Jan. 19, 1933; renewed Aug. 8, 1936). Apparatus for coating a surface of an object with a solid by thermal evaporation of the latter at low absolute pressure comprises an evacuable enclosure provided with means giving access to the interior thereof, means coöperating with the enclosure for evacuating the latter, means within the enclosure for removably supporting an object a surface of which is to be coated, a plurality of filaments within the enclosure, each of the filaments carrying in contacting relation a solid to be vaporized, means for removably supporting the filaments within the enclosure, and means for supplying electric current to any one of the filaments, the apparatus being additionally characterized in that that portion of the surface of the enclosure which is opposite to the object whose surface is to be coated is provided with a plurality of openings closed by removable and interchangeable plugs, a plurality of which carry insulated conductors whose inwardly projecting ends support ends of the filaments.

Porous glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 639,911, Dec. 17, 1936; Cl. 32*b*. 1; *Chem. Abs.*, **31**, 4073 (1937). See Brit. 455,594.

Preventing movement of debiteuse during reheating process. DEUTSCHE TAFELGLAS A.-G. Ger. 641,774, Feb. 4, 1937; D 71,470, VI/32*a*, Gp. 23; *Jour. Soc. Glass Tech.*, **21** [85] A190 (1937).—To prevent the refractory drawing member from rising to the surface while the adjustable metal distance pieces were removed for the purpose of reheating the glass, these are replaced by refractory members inserted between the drawing member and suitable projecting blocks on the side walls of the drawing chamber.

Process and apparatus for making safety glass. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,091,331, Aug. 31, 1937 (Jan. 8, 1936).

Producing even temperature distribution in annealing furnaces. HERZOGENRATHER GLASWERKE BICHEROUX & CIE G.M.B.H. Ger. 642,075, Feb. 11, 1937 (June 8, 1935); H 143,958, VI/32*a*, Gp. 31; *Jour. Soc. Glass Tech.*, **21** [85] A193 (1937).—Heat is communicated to glass articles through walls of good conducting material, *e.g.*, hollow metal conduits through which gaseous or fluid heating medium is circulated.

Regulating the flow of glass in a glassmelting apparatus. ERNST WESSELY. Ger. 641,529, Feb. 4, 1937; Cl. 32*a*. 5; *Chem. Abs.*, **31**, 5966 (1937).

Safety glass. CARBIDE & CARBON CHEMICALS CORP. Fr. 793,175, Jan. 18, 1936; *Chem. Abs.*, **30**, 4289 (1936).—The plastic layer is composed of a partial polyvinyl acetal resin obtained by combining 2.5 to 7 mol. of polyvinyl alcohol with 1 mol. of aldehyde, *e.g.*, butyraldehyde, and a plastifying agent for the resin, insoluble in water, *e.g.*, diethylphthalate. The resin is applied as a solution, *e.g.*, in a mixture of ethylene glycol monoethyl ether and water.

Safety glass. ADOLF KÄMPFER. Fr. 795,358, March 12, 1936; *Chem. Abs.*, **30**, 5382 (1936).—The intermediate layers are formed by mixing appropriate monomeric esters (vinyl acetates and acrylic acid esters) with about 25% of emollients (dibutyl-, diethyl-, dimethyl- and disobutylphthalates and tributylphosphates) and polymerizing in known manner to an intermediate stage, removing the unfixed monomers, and pressing the product into layers on steel or other sheets. The layers are stocked and transported in this form until final incorporation between sheets of glass. After distillation of the unfixed monomers the temperature is rapidly raised to 100° to 120°.

Safety glass. ADOLF KÄMPFER. Fr. 796,950, April 17, 1936; *Chem. Abs.*, **30**, 6522 (1936). The intermediate layer is a polymerization product of high molecular weight and high viscosity, *e.g.*, a polymerized vinyl acetate, of a thickness of about 70% of that of the adjacent sheet of glass, and containing 7 to 20% of emollients of high boiling point (above 170°). In Fr. 753,955, April 18, 1936, the intermediate layer is formed by polymerizing unsaturated organic compounds to about the final degree, dividing and mixing with 20 to 40% of an emollient (phthalic acid ester) at 60° to 70° to obtain a homogeneous mass, and pressing to sheet form at a temperature of 120° to 140°. Fr. 796,962. An adhesive product for joining the intermediate layer to the sheets of glass is composed of the same material as the intermediate layer with the addition of a solvent having a boiling point of at least 100°. In an example, equal parts of polyvinyl acetate and methylglycol are used, and in another polyvinyl acetate 30, polyacrylic ester 20, and methylglycol acetate 50 parts.

Safety glass. PEERLESS SAFETY GLASS CO., LTD. Fr. 792,830, Jan. 11, 1936; *Chem. Abs.*, **30**, 4289 (1936). The intermediate layer is formed of a partly polymerized vinyl resin in solution in a solvent of low boiling point, *e.g.*, AcOBu, and a miscible plastifying agent such as benzyl alcohol. The composition is applied to a sheet of glass, the solvent is evaporated slowly at below 38°, a second sheet of glass is applied, and the whole is heated to 65.5° under pressure.

Safety glass. WALTER PEGLER. Australia 17,280/34, Aug. 1, 1935. JOSEPH L. PEGLER (Walter Pegler, inventor). Fr. 800,925, July 22, 1936; *Chem. Abs.*, **30**, 4289 (1936); **31**, 231 (1937).—The intermediate layer is composed of gelatin containing a plasticizer such as glycerol or diethylene glycol. Formalin may be added as a preservative and (or) to harden the film. An adhesive such as a synthetic resin is applied to the surface of the gelatin, and the second

sheet of glass is applied in a bath composed of a solvent or softener for the resin.

Silica. CORNING GLASS WORKS. Fr. 805,111, Nov. 12, 1936; *Chem. Abs.*, **31**, 3656 (1937). SiO_2 to be used in making glass is introduced in powdered form into an acid solution, a flotation oil comprising a sulfurized derivative of cresol is added, the solution is agitated in a flotation apparatus to eliminate Fe impurities by flotation, and the SiO_2 is dried. Pine oil may be used as a foaming agent in the acid solution.

Sodium resistant glass. LOUIS NAVIAS (Canadian General Electric Co., Ltd.). Can. 367,566, July 27, 1937 (May 16, 1935). G.M.H.

Tank furnace for melting glass. HARTFORD-EMPIRE CO. Ger. 645,106, May 21, 1937; Cl. 32*a*. 1; *Chem. Abs.*, **31**, 5966 (1937).

Tempered glass articles. PILKINGTON BROS., LTD., AND J. B. MITFORD. Brit. 469,994, Aug. 18, 1937 (Jan. 2, 1936).

Tempering glass. PILKINGTON BROS., LTD. Fr. 794,635, Feb. 21, 1936; *Chem. Abs.*, **30**, 5382 (1936). See Brit. 438,389 (*Ceram. Abs.*, **15** [2] 52 (1936)).

Tempering of plate glass or other sheets made of any materials. RAYMOND MEER (American Securit Co.). U. S. 20,499, Sept. 7, 1937 (April 27, 1937); reissue of original 1,999,377, April 30, 1935.

Tools for cutting glass. PATENT-TREUHAND-GES. FÜR ELEKTRISCHE GLÜHLAMPEN M.B.H. Ger. 639,257, Nov. 12, 1936 (May 15, 1935); P 71,266, VI/32*a*, Gp. 33; *Jour. Soc. Glass Tech.*, **21** [85] A198 (1937).—Finely divided crystalline Al_2O_3 is mixed with a softer and more ductile material, pressed to shape, and fired to the softening temperature of the latter.

Tube-working machine. J. DICHTER. Ger. 641,307, Jan. 14, 1937 (Dec. 22, 1934); D 69,397, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [85] A190 (1937).—In a machine in which the tubing is rotated for forming purposes by a roller lying above it, with the axis of the roller at an (adjustable) angle to that of the tubing, the roller is driven from a fixed drive by a flexible shaft, and the adjustment of the angle is about a vertical axis passing through its center.

Structural Clay Products

Abrasive action of sewage on brick sewers. H. C. PLUMMER. *Bull. Amer. Ceram. Soc.*, **16** [9] 365-68 (1937).

Content of soluble salts in brick and the German specification. WALTER MARSCHNER. *Ziegelwelt*, **67**, 23–24 (1936); *Chem. Abs.*, **30**, 3957 (1936).—No efflorescence was found with brick containing less than 0.058% SO_3, while those with 0.16% or more showed it. A method of testing for soluble salts is given. See "Salt—," *Ceram. Abs.*, **16** [1] 19 (1937).

Length of stoneware pipes. J. N. C. MCTAGGART. *Clay Products Jour. Australia*, **4** [10] 9–11 (1937).—In England pipes are 3 ft. in length and in Australia, 2 ft. The duller English climate and the lack of hot winds which prevail in Australia make possible a more uniform drying and thereby a greater length of pipe. H.H.S.

Veneer brickwork. ANON. *Clay Products Jour. Australia*, **4** [10] 25 (1937).—Brick veneer is being used extensively in Australia. It is claimed that this type of house is 14% cheaper than an all-brick house and 7% cheaper than a weatherboard house. Insurance companies accept it as all-brick, since the wood is protected by brick on the outside and by fibrous plaster on the interior. H.H.S.

PATENTS

Brick. SOC. ANON. DES HAUTS FOURNEAUX DE LA CHIERS. Fr. 794,804, Feb. 26, 1936; *Chem. Abs.*, **30**, 5382 (1936).—Brick which have the color, hardness, and other properties of MgO brick are made from CaO. The CaO is brought to a very high degree of fineness either by grinding and sifting or by successive hydrations and dehydrations. An agglomerate having colloidal fineness, *e.g.*, dust from blast-furnace gas or certain clays, is added, and the mixture is dried at 500° to 800°. To facilitate drying, the mixture may be made into brick under a pressure of 100 to 500 kg./sq. cm. and heated to 800° to 1200°. These brick are reground and made into the final brick at a pressure above 2500 kg. and fired at 1350° to 1450°.

Brick mold. J. A. CROWELL (J. B. Crowell & Sons). U. S. 2,091,139, Aug. 24, 1937 (Sept. 26, 1935).

Building blocks and slabs. LONDON BRICK CO., LTD., AND R. S. FRANKS. Brit. 470,593, Sept. 1, 1937 (June 15, 1936).

Cavity brick for building purposes. F. H. HEDINGER. Brit. 469,693, Aug. 11, 1937 (April 16, 1936).

Refractories

Acid Bessemer refractories. J. H. CHESTERS AND R. J. MCLEAN. *Jour. Amer. Ceram. Soc.*, **20** [11] 373–78 (1937).

Alite refractories for the glass industry. V. A. RYBNIKOV AND P. P. ALIMOVA. *Keram. & Steklo*, **13** [4–5] 31–34 (1937).—The characteristics and properties of alite refractories and their manufacture are discussed in detail. The main factors determining the production of high-grade alite brick are their high firing temperature (1460° to 1600°C) and the use of finely granulated alite. The use of coarse-grained alite lowers practically all of the properties of the refractory. The increase of the firing temperature from 1460° to 1600° has no marked effect on the properties of alite refractories; their porosity is somewhat increased, however, while the coefficient of gas permeability is lowered. M.V.C.

Alumina from blast-furnace slag. P. V. GOLUBKOV. *Legkie Metally*, **4** [7] 13–17 (1935); abstracted in *Chem. Zentr.*, **1936, i**, 2166.—Slags from mixes of bauxite, limestone, coke, or charcoal were treated with soda ash in autoclaves; 80 to 90% alumina was extracted after treating with soda for 5 hr. and 30 min. M.V.C.

Bauxite-soda charge *vs.* bauxite-soda-lime charge. A. N. VARSHAVSKIĬ. *Legkie Metally*, **4** [9] 46–52 (1935);

Chem. Abs., **30**, 4630 (1936).—Substitution of bauxite-soda charge at the Volkov alumina plant for the bauxite-soda-lime charge used at the present would increase the cost and decrease the extraction of Al_2O_3.

British exhibits at the Paris International Trade Fair. GENERAL REFRACTORIES, LTD. *Metal Ind.* [London], **48** [26] 725 (1936).—Saxpyre brick for basic open-hearth and electric steel furnaces and insulating brick (Insulite and Amberlite) were shown. These brick play an important part in modern furnace building, owing to their remarkably low thermal conductivity and the enormous heat saving which may be effected by their use. Fire brick of all types, specimen sleeves, nozzles, and stoppers were also shown together with cupola linings and boiler furnace lining material. Of interest to boiler engineers was the display of Durax cement for monolithic work. H.E.S.

Comparison of thermal conductivity and thermal expansion of coke-oven liners made from eastern and western quartzite. J. B. AUSTIN, R. H. H. PIERCE, JR., AND W. O. LUNDBERG. *Jour. Amer. Ceram. Soc.*, **20** [11] 363-67 (1937).

Effect of temperature on the structure of soapstone. HEWITT WILSON AND J. A. PASK. *Jour. Amer. Ceram. Soc.*, **20** [11] 360–63 (1937).

Frit-kiln brick: discussion. HUGILL, *et al. Foundry Trade Jour.*, **54** [1017] 143–44 (1936).—An ideal condition for frit-kiln brick would be for the jointing to have an expansion equal to the shrinkage of the brick. Spalling is caused by sudden heating and cooling of the exposed face of the brick in the frit kiln. Spalling appears to be more prevalent with rotary kilns than with periodic kilns. It is often overcome by the use of a more open brick or a brick of different texture, but other difficulties such as fusion are encountered. The use and advantages of monolithic linings are discussed. For original article see *Ceram. Abs.*, **15** [9] 276 (1936). H.E.S.

High alumina blast-furnace slags. A. D. SOKOLSKIĬ. *Legkie Metally*, **4**, 18–40 (July, 1935); *Metals & Alloys*, **7** [9] MA439 (1936).—Slags containing 50 to 55% Al_2O_3, 40 to 45% CaO, and 3 to 4% SiO_2 can be obtained without difficulty in a blast furnace.

High aluminous clayey substances. SHOICHIRO NAGAI AND JUNZO KATAYAMA. *Jour. Japan. Ceram. Assn.*, **45** [530] 66–77 (1937).—Thirty-five samples of high alumina content were collected from Korea, Manchukuo, and North China. Twelve samples of diaspore were also collected in Japan and Korea. For comparison with these samples of diaspore origin, five samples of kyanite and four samples of bauxite were collected from India. The specific gravities of these 52 samples were determined in two ways, *i.e.*, true specific gravity by powder and apparent specific gravity by lump sample. The chemical compositions of these samples were also determined by the total analysis. Results of chemical analyses and specific gravities of some typical samples are given. From these results, the following points are clearly observed and discussed: (1) the higher the specific gravity, the larger is the content of alumina and the smaller the content of silica in both samples of diaspore and diaspore clay; (2) the contents of TiO_2 and Fe_2O_3 are greater in diaspore clay than in diaspore, so that the specific gravity of the former is about 0.10 greater than that of the latter, by comparing both samples of nearly equal content of alumina; (3) the content of combined water or the amount of loss on ignition of all samples of diaspore and diaspore clay is nearly 14 to 15%, which is an important reason for discussing these samples as being an intimate mixture of diaspore, $Al_2O_3 \cdot H_2O$(H_2O 14.99%), and kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ (H_2O 13.96%), *i.e.*, $xAl_2O_3 \cdot H_2O(1-x)Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$; (4) kyanite, $Al_2O_3 \cdot SiO_2$, and bauxite, $Al_2O_3 \cdot xH_2O$, are high aluminous samples quite different from these diaspore origins, so that their specific gravities and chemical compositions are quite different from those of diaspore origins, etc. The proportion of specific gravity and content of alumina or silica of samples of diaspore origin is fully discussed by the specially designed graphical method, and the simple method of estimation of contents of diaspore and kaolinite parts and amounts of alumina of diaspore base is proposed.

Improved apparatus for measuring conductivities of refractories at high temperatures. J. L. FINCK. *Jour. Amer. Ceram. Soc.*, **20** [11] 378–82 (1937).

Local reactions of slag with furnace refractories. H. JEBSEN-MARWEDEL. *Feuerungstechnik*, **25** [3] 78–79 (1937).—The resistance of refractories to slag attack depends on the manner in which they are laid, when using several kinds of refractories in a tank. The reactions taking place in a 3-compound system, SiO_2–Al_2O_3·R_2O (flux), are discussed and a diagram is given. Illustrated. M.V.C.

Mullitization of grog brick. L. M. BLUMEN. *Keram. & Steklo*, **13** [4–5] 27–30 (1937).—Attempts to use protective coats containing feldspar to increase the density of grog brick for tank furnaces are discussed. The experiments showed that the brick were well protected and not attacked by molten glass. The surface of grog brick coming into contact with the protective coat was covered with a thin porcelain-like white layer of mullite. The results are tabulated. M.V.C.

Preparation of porous refractories from kieselguhr or similar material and their use as carriers in chemical processes in comparison with natural porous minerals such as pumice, as well as their behavior when variously impregnated. HEINRICH HERBST. *Feuerungstechnik*, **23**, 97–100, 111–15 (1935); *Chem. Abs.*, **30**, 6519 (1936).—The distribution of caustic solution used in impregnating the grains of various carriers made of diatomaceous earth was studied by noting the electrical resistance of a definite volume of the material. Up to about 30% H_2O, the resistance and the Cl-absorbing capacity increase steadily; most of the solution is in the interior of the grains. Above a certain point the resistance rises rapidly and the capacity falls off; at this point the grain surfaces become covered with liquid, although they appear dry to the touch. Pumice is less suitable for gas-absorbent material, as there is not enough connection between the interior and the surface of the grain. The preparation of the grains is described.

Recent developments in refractories. CHRISTOPHER E. MOORE. *Proc. Staffordshire Iron Steel Inst.*, **51**, 74–90 (1935–36); *Chem. Abs.*, **31**, 4071 (1937); for abstract see *Ceram. Abs.*, **15** [5] 154 (1936); **16** [10] 304 (1937).

Refractory cements and mortars: I. SHOICHIRO NAGAI AND JUNZO KATAYAMA. *Jour. Japan. Ceram.*

Assn., **44** [523] 441–53 (1936).—Nine samples of refractory cements were analyzed by the common method of total analysis and the results obtained are given in a table. These results show that these nine samples can be divided into three classes: (*a*) high alumina (about 60 to 68%) and low silica (about 29 to 33%), (*b*) medium alumina (about 37 to 47%) and silica (about 40 to 53%), and (*c*) low alumina (about 14 to 25%) and high silica (about 63 to 75%). Samples of the first class have little loss on ignition. Six samples were tested with regard to their specific gravities and grain distributions by the sieving method. The results are given in a table. The fineness or grain distribution varies but there are generally larger amounts of coarse grain greater than 900 mesh./ cm.^{2}, fine powder smaller than 4900 mesh./cm.^{2}, and a relatively small amount of medium grain between 900 and 4900 mesh./cm.^{2} The samples of refractory cements were kneaded with enough water to mold test pieces 6 cm. in length, 3 cm. in breadth, and about 1 cm. in thickness, and their drying and firing shrinkages were tested.

Refractory and ceramic uses of fused silica. W. W. Winship. *Bull. Amer. Ceram. Soc.*, **16** [9] 351–61 (1937).

Refractory linings with a high alumina content. N. P. Krasnikov and B. L. Gershman. *Keram. & Steklo*, **13** [6] 24–27 (1937).—The use of andalusite, kyanite, and sillimanite refractories in the glass industry and the effect of molten glass on these materials are discussed. Attempts to use an andalusite protective coat for grog refractories of tank furnaces and pots are described. The results obtained were unsatisfactory because of the difference in the physicochemical properties of the andalusite and grog used, especially the coefficient of expansion. At high temperatures the linings crack, and the molten glass penetrates and intensively corrodes the grog blocks.

M.V.C.

Refractory materials in the glass industry. Hector Bolognini. *Industria & quim.* [Argentina], **1**, 42–46 (1935); *Chem. Abs.*, 30, 4637 (1936).—A review is given.

Relative thermal expansion of shell, coating, and lining brick of the cement rotary kiln: I. T. Yoshii and I. Iwakiri. *Jour. Soc. Chem. Ind. Japan*, **40** [5] 171–72B (1937).—Results of expansion measurements made with a dilatometer on test specimens of lining and coating brick from a rotary kiln are shown in diagrams, and the formula for calculating the expansion coefficient is given.

M.V.C.

Secondary expansion in refractory clays. J. O. Everhart. *Jour. Amer. Ceram. Soc.*, **20** [11] 353–59 (1937).

Testing refractory materials under load. T. M. Firkin. *Commonwealth Engr.*, **24**, 163–68 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 2236.—A comprehensive description of testing methods developed in Germany, Great Britian, and the U. S. is given. M.V.C.

Theory of regenerators. J. Lamort. *Z. Tech. Physik*, **17**, 164–66 (1936).—The formula derived by Schack permits the computation of the influence of a layer of dust on the regenerator lining. This formula has been simplified, assuming perfect heat conduction of the refractory material. W.M.C.

BOOK

Open-Hearth Furnace: Vol. 2. William C. Buell, Jr. Penton Publishing Co., Cleveland, 1936. 276 pp. Price $4.15. Reviewed in *Jour. Western Soc. Engrs.*, **42** [2] 90 (1937).—This material was first published in *Steel* (*Ceram. Abs.*, **15** [5] 152 (1936); **16** [1] 22 (1937)).

PATENTS

Article of self-bonded granular material and method of making. R. R. Ridgway and B. L. Bailey (Norton Co.). U. S. 2,091,569, Aug. 31, 1937 (Sept. 30, 1935). The method of making a shaped refractory article of an oxide of a metal of the group consisting of aluminum, magnesium, zirconium, titanium, thorium, cerium, and chromium comprises the steps of enclosing the refractory metal oxide in a granular condition and of required purity in a mold space, heating the material, while subjecting it to pressure within the mold, to a temperature close to its melting point and at which it is plastic and compacting it into an integral mass, and as soon as it has been compacted cooling the molded body to a point materially below its melting point.

Ceramic materials. Jenaer Glaswerk Schott & Gen. Fr. 792,867, Jan. 11, 1936; *Chem. Abs.*, 30, 4289 (1936).—Materials rich in SiO_2 are heated to vitrification at a temperature below their freezing point and then cooled at such a speed that there is not produced in the material rich in SiO_2 a crystallization influencing in an unfavorable manner the coefficient of expansion.

Ceramic products. Magnesital G.m.b.H. Fr. 791,916, Dec. 19, 1935; *Chem. Abs.*, 30, 4289 (1936). Refractory brick, etc., are made more resistant to sudden changes of temperature by subdividing the surface in the form of a honeycomb, the maximum size of the cells being between 2 and 10 cm.^{2} with a depth of 2 to 4 cm.

Checkerwork construction. G. L. Danforth, Jr. (Open Hearth Combustion Co.). U. S. 2,090,832, Aug. 24, 1937 (March 2, 1936).

Composite refractory body. H. E. Mendenhall (Bell Telephone Laboratories, Inc.). U. S. 2,091,554, Aug. 31, 1937 (Oct. 3, 1935). A composite refractory body comprises a plurality of layers of pure thorium separated by a layer of tungsten.

Fire-resistant insulating material. H. L. Becher (Homasote Co.). Can. 367,612, July 27, 1937 (May 15, 1936). A porous agglomerate comprises about 94% by weight exfoliated vermiculite and about 6% gelatinized cellulose. G.M.H.

Furnace wall. A. H. Stewart. U. S. 2,092,537, Sept. 7, 1937 (Oct. 14, 1935). A refractory body of clay, etc., has metallic heat-conducting members extending inwardly from an exposed surface thereof, a sprayed metal coating on the surface having engagement with the outer ends of the surface, and a metallic facing sheet fused to the coating.

Manufacture of refractory products. C. Arnold (Non-Metallic Minerals, Inc.). Brit. 470,028, Aug. 18, 1937 (Feb. 8, 1936).

Method of graphitizing carbon bodies. R. L. Melton (Carborundum Co.). U. S. 2,090,693, Aug. 24, 1937 (Dec. 28, 1934). A process of graphitizing carbonaceous bodies comprises subjecting such bodies to heat treatment at a temperature sufficiently high to produce graphitization and measuring the electrical resistance of the body to an

induced electrical current while at such elevated temperature.

Merwinite refractories. H. C. LEE (Non-Metallic Minerals, Inc.). Can. 358,403, June 9, 1936; *Chem. Abs.*, **30**, 5383 (1936). One of several examples follows: Dolomite 400 parts by weight and silica sand 83 parts by weight, proportioned to give 1.4 parts of lime for each part by weight of silica, are ground in a ball mill with water until a substantial portion passes a 200-mesh screen. In slurry form it is fed to a rotary kiln fired at 2800°F to form a dense, hard, light brownish gray clinker; this is crushed to pass a 6-mesh screen, tempered with 6 to 8% water, pressed into brick, dried, and fired at cone 14 to 16. The product consists of crystals of merwinite intermixed with periclase. It withstands higher temperatures than fireclay refractories, is resistant to open-hearth slags, has a lower thermal conductivity than magnesite refractories, and possesses slight hydraulic properties.

Process of aluminum recovery from aluminum silicates. R. C. FOLGER (Electric Smelting & Aluminum Co.). Can. 367,573, July 27, 1937 (May 31, 1935); see *Ceram. Abs.*, **16** [1] 25 (1937). G.M.H.

Recuperator tile structure. W. A. MORTON AND H. F. SPENCER (Amco, Inc.). U. S. 2,092,402, Sept. 7, 1937 (Aug. 7, 1934).

Refractory. F. A. HARVEY AND R. E. BIRCH (Harbison-Walker Refractories Co.). Can. 367,768, Aug. 3, 1937 (June 11, 1936); see *Ceram. Abs.*, **16** [7] 209 (1937). G.M.H.

Refractory and ceramic products. MAX FOUQUEMBERG. Fr. 805,496, Nov. 20, 1936; *Chem. Abs.*, **31**, 4469 (1937). The usual thinners (chamotte, refractory clay, refractory brick, etc.) used in making refractory and ceramic products are replaced by slags or ashes in the form of an impalpable powder.

Refractory masonry for metallurgical furnaces. AIMÉ P. J. FRANÇOIS-BONGARÇON. Fr. 791,785, Dec. 17, 1935; *Chem. Abs.*, **30**, 4290 (1936). Construction of the masonry, particularly for blast furnaces, is described.

Refractory materials. VICTOR M. GOLDSCHMIDT. Ger. 623,644, Dec. 31, 1935; Cl. 80*b*. 8.08; *Chem. Abs.*, **30**, 5010 (1936). Natural materials rich in Mg_2SiO_4, *e.g.*, olivine, and containing not more than 10% FeO are mixed with salts of alkali, alkaline earth of tri- or quadrivalent metals, or mineral acids, molded, fused by heating to high temperatures, and allowed to crystallize to form fire-resisting masses. The heating may be carried out in an oxidizing atmosphere or an alternating oxidizing and reducing atmosphere. Thus, ground olivine is mixed with 2 to 5% of Na_2SiO_3 solution, molded, heated to 1000°, and allowed to cool.

Refractory objects. MARCEL GROSJEAN. Fr. 792,687, Jan. 7, 1936; *Chem. Abs.*, **30**, 4290 (1936). Casting ladles, crucibles for induction furnaces, etc., are made by mixing powdered zircon (Zr silicate) with H_3PO_4 as binder, pressing, and heating to fritting temperature. Dextrin may be used as binder in part of the structure.

Refractory products and preparation. W. W. PATNOE (Basic Dolomite, Inc.). U. S. 2,091,610, Aug. 31, 1937 (July 8, 1933). A process of preparing free-flowing, comminuted, granular refractory materials comprises firing dolomite, etc., to clinker, cooling it, and subsequently coating the surfaces of the clinker particles with a mineral oil, the amount of oil being such that the free-flowing granular condition of the clinker is preserved and the air slacking tendency is counteracted.

Refractory stone. GEORGE M. CARRIE, JAMES W. CRAIG, ARTHUR C. HALFERDAHL, AND FRANK E. LATHE. Ger. 624,763, Jan. 28, 1936; Cl. 80*b*. 8.01; *Chem. Abs.*, **30**, 5011 (1936). The above is made by molding and firing a mixture of 70 parts of ground MgO clinker containing about 18% CaO and 30 parts of ground Cr-Fe ore.

Walls of furnace-heated water-tube boilers and like heat exchangers. BABCOCK & WILCOX, LTD. Brit. 469,875, Aug. 18, 1937 (Nov. 28, 1934).

Terra Cotta

Breakages in drying roofing tile. F. REUMANN. *Tonind.-Ztg.*, **61** [33] 373–75 (1937); *Brit. Chem. Abs.-B*, **56**, 549 (June, 1937).—The feeding ducts to presses should be free from sharp corners and dead spaces, as any shearing action leaves microscopic cavities in the clay which develop into cracks on drying. Regulation of the humidity in drying chambers also reduces breakages.

British Chemical Plant Exhibition, 1936. DOULTON & CO., LTD. *Ind. Chemist*, **12** [138] 330 (1936).—A high degree of accuracy is now obtainable in machining white stoneware. Large taps and ball mills, ground to an accuracy of 1/1000 in., are shown. A salt-glaze stoneware transport jar with a capacity of 440 gal. illustrates the size in which stoneware is now obtainable. Another exhibit is a fluted white stoneware roller for dyeing textiles and similar operations. H.E.S.

Chemical composition of medieval tile glazes. W. GANZENMÜLLER. *Angew. Chem.*, **50**, 260–63 (1937); *Chem. Abs.*, **31**, 4072 (1937).—The colors were produced by the use of SiO_2, Pb, Sn, Cu (green, with Pb, yellow) Fe, Co, and Ag. See "Secrets—," *Ceram. Abs.*, **16** [8] 241 (1937).

Exclusion of solar heat: III, Reflectivities of building materials for solar radiation. H. E. BECKETT. *Jour. Inst. Heating Ventilating Eng.*, **3**, 84–88 (1935); *Chem. Abs.*, **31**, 4472 (1937).—The reflection coefficients for clay tile, concrete tile, slates, various roofing materials, brick, stones, and paints are given.

Influence of age on the permeability of roofing tile to water. FRITZ WEISE. *Tonind.-Ztg.*, **60**, 298 (1936); *Chem. Abs.*, **30**, 4638 (1936).—Tile, originally porous, became more impervious to water with exposure up to 11 years, owing largely to the accretion of dust.

Influence of compositions of underslips, glazes, and bodies on blistering and other spraying defects. H. G. SCHURECHT AND J. F. MCMAHON. *Jour. Amer. Ceram. Soc.*, **20** [10] 344–48 (1937).

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. Translated in *Brit. Clayworker*, **46** [544] 144–46 (1937).—The operation of intermittent kilns, with

details as to the water-smoking period, raising the heat period, and the full fire period, is discussed. Directions are given to obtain best results in each stage. See *Ceram. Abs.*, **16** [10] 309 (1937). R.A.H.

Progress in chemical equipment in Germany. J. HAUSEN. *Eng. Progress*, **18** [6] 115–24 (1937).—H. discusses (1) the rôle of stainless, acid-resisting steels and plated sheet metal in the construction of chemical equipment, (2) improvements in quartz ware, (3) use of stoneware, (4) apparatus heated by high-pressure steam, (5) drying processes, (6) screening technique, (7) filtering, (8) centrifuging, (9) clarifying, (10) crushing, (11) acid pumps, (12) evaporators and heat exchangers, (13) laboratory utensils and equipment, (14) measuring instruments, (15) chemical analysis and optical aids, and (16) research work. A bibliography of 36 references and 14 photographs of recent chemical and ceramic equipment are given. J.L.G.

Resistance of roofing tile to freezing. A. GALLASCH. *Ziegelwelt*, **67**, 207–208 (1936); *Chem. Abs.*, **31**, 4072 (1937).—Resistance to freezing depends upon the diameter of the pores and the shape of the openings and not upon the total porosity or the degree of firing.

PATENT

Waterproofing brick, tile, etc. ÉTABLISSEMENTS KOLB-CARRIÈRE. Fr. 793,307, Jan. 22, 1936; *Chem. Abs.*, **30**, 4640 (1936). Constructional materials are proofed by means of an insoluble metal soap, fused or dissolved in a fat substance, wax, or resin.

Whiteware

Ceramic materials for insulators. ANON. *Electronics*, **10** [2] 7–10 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 4003.—The following materials and their properties are dealt with: (1) porcelain, (2) aluminum-magnesium silicate porcelain (steatite), (3) mica, and (4) fused quartz, aluminum, and magnesia. M.V.C.

Comparison of glass and crystal with respect to resistivity. S. MORIYASU. *Jour. Japan. Ceram. Assn.*, **45**, 149 (1937); *Jour. Soc. Glass Tech.*, **21** [85] A207 (1937).—The resistivities of feldspar and quartz are measured in the glassy and crystalline states. For feldspar, the relation between resistivity and temperature is represented by the following equations:

$$\text{Feldspar} \begin{cases} \text{crystal: } \log \rho = 4.6 \times 10^3/T + 2.6 \\ \text{glass: } \log \rho = 4.6 \times 10^3/T - 2.1 \end{cases}$$

For quartz, the resistivity of the glass is the same as that of crystal within experimental error. From these results and those of the previous investigations as to Al_2O_3–SiO_2–alkalis and MgO–Al_2O_3–SiO_2–alkalis systems, it is concluded for porcelain that conduction greater than 10 mho/cm. at 400° is due to alkali ions in the glassy phase.

De-airing porcelain mixes. LUDWIG SCHNELLER. *Sprechsaal*, **70** [12] 155–58 (1937).—S. discusses the advantages of working ceramic mixes in vacuum presses which have been greatly perfected. Details of construction are given. Illustrated. M.V.C.

Effect of iron and its compounds on the color and properties of ceramic material and engobes. T. N. MCVAY AND C. W. PARMELEE. *Jour. Amer. Ceram. Soc.*, **20** [10] 336–44 (1937).

Improving the quality of porcelain ware. G. K. TERESCHENKO AND G. V. SHUTYĬ. *Keram. & Steklo*, **13** [6] 27–33 (1937).—It was found that porcelain mixes prepared from pure kaolin without additions of plastic clay but treated by vacuum presses are highly plastic. These mixes are easily worked, and their shaping capacity is similar to that of mixes with a content of plastic clay. Vacuum mixes have a higher coefficient of adherence, and the coefficient of outside and inside "rubbing" is increased. De-aired mixes no longer require storing. Thermal treatment showed that increase of the degree of de-airing of mixes increases the density of the bodies. De-airing lowers porosity and increases the mechanical strength of the bodies. A comparison of the indices of whiteness of ordinary bodies and those treated in a vacuum showed that the latter have a higher index. M.V.C.

Manufacture of porcelain in Hungary; domestic kaolin. ISTVÁN L. GYÖPÖS. *Vegyi Ipar*, **35** [5] 4 (1936); *Chem. Abs.*, **30**, 5378 (1936).—From crude kaolin from the Sárospatak deposit 39% first-grade and 22% second-grade kaolin could be obtained by electroösmosis. Yields from the Mátraderecske deposit were 26.2 and 61.2%. The plasticity and refractoriness of the first-grade products were equal to those of Zettlitz kaolin.

Operation of an electric furnace for color-firing for porcelain, etc. A. WLOST. *Elektrowärme*, **7** [7] 145–47 (1937).—A furnace of 22 kw. for 820°C was used for firing colors on tile, vases, objects of art, etc. The colors were very clear as no CO or S vapors were present. No rejects, cheaper operation, and less supervision and maintenance are claimed. M.H.

Porcelain factories of Tournai in the 18th Century. H. JAVAUX. *Verre & Silicates Ind.*, **7** [36] 430–31 (1936).—J. takes issue with the article of Nicaise (*Ceram. Abs.*, **16** [4] 107 (1937)) on this subject in which he asserted that the annexation of Belgium by France ruined the industry and factory of Peterinck who was producing famous artistic porcelain. J. claims that the breakdown was brought about by other causes, *e.g.*, poor administration and internal trouble, since other factories of the period survived and flourished. H. NICAISE. *Verre & Silicates Ind.*, **8** [2] 19–20 (1937).—N., in rebuttal, reasserts his original contention and points out that those factories which survived in the new régime produced ware not comparable with the artistic work of Peterinck who was unable to continue to produce his famous ware under the new conditions. M.V.C.

Rate of drying of porcelain ware from de-aired mixes. A. I. AVGUSTINNIK AND P. S. POTEMKIN. *Keram. & Steklo*, **13** [4–5] 38–39 (1937).—The results of experiments show that (1) a temperature of 70°C and a speed of 1.2 m./sec. of the air are satisfactory for the artificial drying of ware from de-aired mixes; (2) the rate of drying of porcelain ware decreases linearly with increasing degree of de-airing; and (3) the de-airing of porcelain mixes heightens the critical temperatures. M.V.C.

Review of ceramic materials for high-frequency insulation. HANS THURNAUER. *Jour. Amer. Ceram. Soc.*, 20 [11] 368-72 (1937).

Talc porcelain: V-VIII. SEIJI KONDO AND SHIN-ICHI SUZUKI. *Jour. Soc. Chem. Ind. Japan*, 40 [4] 149-51B (1937).—The results of supplementary experiments on highly talcous and all-talc bodies and on absorption, thermal endurance, linear thermal expansion, modulus of rupture, true specific gravity, and specific electric resistance of test specimens of cordierite are given. Similar experiments were made on cordierite-like bodies whose kaolin was largely or partly replaced by Al_2O_3 or Al_2O_3 and MgO. The microstructure of ignition plug insulators on the market is discussed. For Parts III-IV see *Ceram. Abs.*, 16 [6] 180 (1937). M.V.C.

Use of alumina for bedding. N. W. ELLIOTT. *Pottery & Glass Record*, 19 [8] 198-200 (1937).—E. gives a historical account of the substitution of alumina for flint in bedding (placing) pottery in saggers and the technical, economic, and health advantages to be gained. A special warning is given against allowing any flint to become mixed with the alumina. A.B.S.

PATENTS

Electrical insulator. ANDREW MALINOVSZKY. U. S. 2,092,982, Sept. 14, 1937 (June 8, 1936).—An electrical strain insulator comprises a cylindrical body of ceramic composition adapted to envelope and support in spaced relation two interlinked U bolts and having a portion of its ceramic mass interposed therebetween.

Porcelain. MINISTER OF COMMUNICATIONS (Takeo Kanno, inventor). Japan. 113,969, Jan. 13, 1936; *Chem. Abs.*, 30, 5383 (1936).—The porcelain is made of oxides of Si, Al, Fe, Ca, Mg, K, Na, and Zn. The content of ZnO is limited to 4 to 20% and the ratios SiO_2:Al_2O_3 and Al_2O_3:ZnO are made almost equal. The product is mechanically strong.

Sanitary appliances such as wash basins, baths, etc., having hot and cold water supply taps. CHARLES MALLET (Établissements Jacob-Delafon Compagnie Céramique de Pouilly-sur-Saône et Belvoye). U. S. 2,091,553, Aug. 31, 1937 (March 6, 1936).

Equipment and Apparatus

Apparatus for precise plasticity measurements at high temperatures. Data on coal plasticity. H. K. GRIFFIN AND H. H. STORCH. *Ind. Eng. Chem., Anal. Ed.*, 9 [6] 280-86 (1937).—An instrument for precise measurements of plasticity at elevated temperatures is described. Adequate apparatus is included for avoiding eccentric loading. Measurements made on Pittsburgh and Alma seam coals show that the truly plastic properties of these coals are very transient, the life period being of the order of 1 min. at 460°C. Measurements of deformations proportional to the load were obtained at 410°C. An analysis of these data indicates that the deformations are elastic rather than plastic in character. Measurements on the deformation of the solid plus oily bitumen (obtained by benzene extraction) of Pittsburgh seam coal at 120°C show that this is a truly plastic material. Illustrated. F.G.H.

Automatic recording balance. D. S. BINNINGTON AND W. F. GEDDES. *Ind. Eng. Chem., Anal. Ed.*, 8 [1] 76-79 (1936).—An automatic, electrically operated, continuous recording balance fitted with oil damping and counterbalanced for an initial load of 100 g. is described. Losses in weight up to 17 g., with an accuracy in the order of 0.01 g., are recorded without manual attention by means of an automatic device which places weights in the form of steel bearing balls upon the pan. Recording is performed through the use of a timed spark upon a paper chart carried on the drum of a variable-speed kymograph which has a range of from 12 hr. to 6 days. Illustrated. F.G.H.

Construction and operation of a simple pyrometer system. E. C. CLEMENS. *Bull. Amer. Ceram. Soc.*, 16 [9] 368-70 (1937).

Continuous *versus* periodic filtering. G. G. KENT AND E. M. RUPP. *Bull. Amer. Ceram. Soc.*, 16 [10] 390-92 (1937).

Conveyers at clay pits. ANON. *Clay Products Jour. Australia*, 4 [10] 14 (1937).—Sectional belt conveyers, as made by Mavor & Coulson of Glasgow, Scotland, are said to have completed the mechanization of clay pits. The conveyer links the excavator to the brick-making machinery and abolishes tubs and haulage. The whole plant for digging and carrying the clay, consisting of a multi-bucket excavator and two conveyers, is run by one man. H.H.S.

Drying by spraying or atomization. A. ANTONI. *Chem. Eng. Congress World Power Conference, C*19, 26 pp. (1936); *Chem. Abs.*, 31, 3742 (1937).—A. gives a detailed discussion of the mechanism and laws for spray drying. The two main methods of producing the spray—a jet under pressure or centrifugal force—are illustrated with commercial apparatus. The application of spray drying is being rapidly extended to powdered foods, cement, refractories, milk, and soap industries. See also *Ceram. Abs.*, 15 [5] 161 (1936).

Evolution of various types of crushers for stone and ore, and the characteristics of rocks as affecting abrasion in crushing machinery: I-II. W. T. MILLER AND R. J. SARJANT. *Trans. Ceram. Soc.*, 35 [11] 492-560 (1936).—A variety of types of crushers including double and single toggle jaw, long and short gyratory, disk, and swing hammer crushers, gear and belt driven crushing rolls, and single roll breakers are described with respect to their origin, stages of development, use, and performance. An analysis of existing data relating to the testing of road-making stones from its bearing on the abrasive wear of crusher parts is presented and an experimental investigation correlating the abrasive wear as encountered in practice with the physical and petrological characters of rocks is described. The results of tests made in determining the resistance to crushing of refractory materials are given in an appendix. A correlation has been found between resistance to crushing as expressed by the average grain size of the crushed produced and impact value. Illustrated. R.H.H.P., JR.

Figuring and correcting mirrors by controlled deposi-

tion of aluminum. JOHN STRONG AND E. GAVIOLA. *Jour. Optical Soc. Amer.*, **26** [4] 153–62 (1936).—The process of coating the surfaces of mirrors, prisms, and diffraction gratings with metal films by evaporation can be utilized not only to obtain a uniform film, but also to deposit a known and controlled, nonuniform coat and permanently modify the figure of an optical surface. The technique and results are described. The method has a wide field of possible applications. Its main limitation is the appearance of bloom at a layer thickness of 5 wave-lengths. A.P.

Horizontal revolving kiln; an improved ore roaster. H. J. BUSH. *Ind. Chemist*, **12** [137] 266–69 (1936). H.E.S.

Improved method of drying clay. ANON. *Brit. Clayworker*, **46** [544] 148–50 (1937).—The invention described in this article and known as the D.P. patent drying oven, has been in use for several years in Belgium and France for drying completely all types of clay such as kaolin, fire clay, and other ceramic clays by means of a non-mechanical drier with a simple furnace. By its use a notable economy in fuel consumption and power is realized. A detailed description of the furnace and equipment is given. R.A.H.

Improvements in the integrating photometer for X-ray crystal analysis. R. H. V. M. DAWTON. *Jour. Sci. Instruments*, **14** [6] 198–200 (1937).—D. describes improvements in the integrating photometer, particularly the substitution of a mechanical clutch with magnetic release for the original magnetic clutch. Illustrated. J.L.G.

Improving the working of tile and grog mixes. HERMANN HARKORT. *Tonind.-Ztg.*, **61** [35] 397–98 (1937).—H. discusses a new method for working ceramic slips over a bed of sand used as a filter and under which lies a porous web made of metal or other material [Ger. Pat. 625,318 (*Ceram. Abs.*, **15** [8] 252 (1936)) and 635,728]. M.V.C.

Inexpensive ball mill. LAURENCE L. QUILL. *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 27 (1936).—Q. describes a portable ball mill adaptable for use with ball mill jars of various sizes. Illustrated. F.G.H.

Inexpensive metal chimney for fusions. LOUIS J. CURTMAN AND LEO LEHRMAN. *Ind. Eng. Chem., Anal. Ed.*, **9** [5] 225 (1937).—A device is described for use in making fusions using a Méker or Tirrill burner as a source of heat. It is particularly serviceable where a high temperature must be maintained, as in the decomposition of a silicate with sodium carbonate. Illustrated. F.G.H.

Insulation testing; studies of 50-cycle wave form. N. H. ROBERTS. *Trans. Roy. Soc. S. Africa*, **24** [4] 313–24 (1937).—It is now recognized that wave form is of great importance in testing the breakdown of solid dielectrics. A sinusoidal voltage wave is desirable. Experiments are described on the conditions which influence a 50-cycle wave form. H.H.S.

Linings for ball grinders made of cast-iron and held together by pins. A. DESPLANCHER. *Ciment*, **40**, 86–88 (1935).—So far manganese steel has been used almost universally to line ball grinders. This material is disadvantageous in many respects, *e.g.*, it is comparatively ductile and the percussion of the balls produces a lamination and flowing of the material. The metal fills the space between the plates. The tubes sometimes break. In contrast thereto, plates made from white, extra-hard cast iron have given excellent results. These plates, which must of necessity be thicker and therefore heavier, require a strong, well-built tube. It is necessary to dispense with bolts to fasten the plates. The best method to hold the plates in place is the use of pins. At the ends of their arches, the plates are provided with a groove into which a piece of round steel of about 20 mm. diameter is forced. A drawing illustrates the arrangement. Cement factories will find that these somewhat flexible plates will give at least the same results as those of manganese steel. It is claimed that the plates described above last from 4 to 6 yrs. for continuous service, thus saving time in mounting and dismounting. E.ST.

Low-resistance glass electrodes. H. MOUQUIN AND R. L. GARMAN. *Ind. Eng. Chem., Anal. Ed.*, **9** [6] 287 (1937).—The procedure for making a low-resistance glass electrode is given. Electrodes made in this manner are fully as satisfactory as the traditional types, with the additional advantage that the measurements may be made with the ordinary potentiometer and a portable galvanometer of medium sensitivity. Illustrated. F.G.H.

Measurement of the aberrations of a microscope objective. R. KINGSLAKE. *Jour. Optical Soc. Amer.*, **26** [6] 251–56 (1936).—A definite figure of merit for the excellence of a microscope objective will avoid the personal factor inherent in the usual visual tests and indicate if the product is as good as its design. Such a figure is best determined by measuring the actual spherical aberration of the objective and calculating from it the curve of optical path difference against aperture relative to the "best focus." Comparing this with the Rayleigh quarter-wave limit yields a significant figure of merit. The new method with its limitations and precision is discussed. The Foucault knife-edge test was found to be readily adaptable to the measurement of the chromatic aberration. Typical curves for all of these tests are given. A.P.

Metallographic microscope of exceptional power. F. F. LUCAS. *Bell Lab. Record*, **15** [4] 103–107 (1936); *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 94, p. 24 (1937); see "Developments—," *Ceram. Abs.*, **15** [6] 191 (1936).

Method for measuring thermal conductivity of insulating materials. J. A. WEH. *Gen. Elec. Rev.*, **40** [3] 138–41 (1937).—A direct electrical method of measuring the thermal conductivity of a single specimen of the test material (concrete, sand, textolite, Mycalex, etc.) has been developed. The apparatus consists of hot and cold plates. The function is to set up a temperature drop across the sample and thus cause a flow of heat. The hot plate is electrically heated. The procedure, results, and accuracy of this new device are discussed. Illustrated. L.E.T.

Method of studying wetting of powdered minerals as related to flotation. I. R. KLYACHKO AND V. I. TRUSHLEVICH. *Gorno-Obogatitel. Zhur.*, No. 6, pp. 28–32 (1936); *Chem. Abs.*, **31**, 3338 (1937).—The purpose of this experiment was to determine the relationship between the results of flotation and the hysteresis values of wetting of concentrate and tailings. Method: The mineral powder is glued to the surface of a glass plate by means of Canadian balsam. The temperature at which the mineral grains are glued to the molten balsam has no effect upon wetting. The glass is washed with H_2O for 10 min. The stability of the plate is controlled by the addition of 2 to 3 drops of

H_2O; the values of wetting should not differ by more than 5 to 10%. After this preliminary testing, the concentrate and tailings plates are placed for 5 min. in separate portions of a solution containing the same combination of reagents which was used in flotation. Both plates are carefully dried with filter paper, drops of H_2O are added, and the wetting is determined. The drops should be added from a buret, the tip of which is 0.5 cm. from the plate; the rate of flow should be 1 drop/30 sec. The wetting can be determined without the flotoreagents or after their preliminary adsorption. The difference between the hysteresis wetting of the concentrate and the tailings is related to the results of flotation and may be used to control the latter. When the difference is more than 0, flotation is possible; the greater the difference, the better is the separation. When the difference is less than 0, the rock enters the concentrate.

Microchemical balance room. W. R. KIRNER. *Ind. Eng. Chem., Anal. Ed.*, **9** [6] 300–303 (1937).—The construction of the microchemical balance room of the Coal Research Laboratory of the Carnegie Institute of Technology is described. Illustrated. F.G.H.

Operation of analytical microbalances highly sensitive to temperature changes. FRITZ BREUER. *Ind. Eng. Chem., Anal. Ed.*, **9** [7] 354 (1937). F.G.H.

Pendulum as a source of energy for plasticity measurements. IRA WILLIAMS. *Ind. Eng. Chem., Anal. Ed.*, **8** [4] 304–306 (1936).—A pendulum of known potential energy is used to produce a definite, rapid deformation in a plastic material. The damping effect produced on the pendulum is a measure of the energy expended to produce the deformation. The elastic recovery following the rapid deformation is much greater than that obtained with the ordinary parallel-plate instrument. The actual measurement of the energy consumed and elastic recovery requires less than 1 min. Samples should be brought to a uniform temperature by preheating for at least 10 min. at the temperature of the test. Illustrated. F.G.H.

Physics and technique of air separation. H. W. GONELL. *Chem. App.*, **24** [12] 193–97 (1937).—G. explains the physical principles of separating particles of different sizes of dust and powdery materials by an air current and describes practical applications and apparatus. M.H.

Polarizing characteristics of Polaroid plates for wavelengths 4000 Å to 20,000 Å. L. R. INGERSOLL, J. G. WINANS, AND E. H. KRAUSE. *Jour. Optical Soc. Amer.*, **26** [6] 233–34 (1936).—The polarizing property of Polaroid is found to be limited almost entirely to the visible spectrum, dropping off very rapidly in the infra-red and violet regions. A.P.

Sedimentation equilibrium in the simplest air-driven tops. JAMES W. MCBAIN AND CLAUDIO ALVAREZ-TOSTADO. *Nature*, **139** [3529] 1066 (1937).—The device described is a simple ultra-centrifuge for use in measuring sedimentation equilibrium of particles of all sizes from the smallest molecules in solution to the largest colloids. J.L.G.

Simple portable aradient convection pyrometer. FRANK T. BARR AND RICHARD F. BERGER. *Ind. Eng. Chem., Anal. Ed.*, **8** [5] 393–95 (1936).—This pyrometer, termed an aradient convection pyrometer, is designed to minimize the effect of radiant energy absorption and increase the transfer of heat by convection. Illustrated. F.G.H.

Surface calorimeter. H. TINSLEY AND CO. *Jour. Sci. Instruments*, **14** [6] 214 (1937).—This apparatus measures the heat radiated from an insulated surface. A surface of known emissivity is superimposed on the surface of unknown emissivity. The temperature of the surface of known emissivity is then measured by means of a resistance thermometer. The instrument is calibrated in approximately 17 B.t.u./ft. sq./hr. for 0.1 ohm steps on the instrument dial for a resistance band of 5 ohms. The bridge unit weighs 12½ lb. Price of complete equipment is £20. J.L.G.

Transmission curves for the new polarizers. JOHN STRONG. *Jour. Optical Soc. Amer.*, **26** [6] 256 (1936).—Transmission curves from 3000 to 11,000 Å in the parallel and crossed positions are given for two commercial Nicol prism substitutes. The crossed films could be used as a filter to isolate the visible radiations from the infra-red. See "Polarizing—," this issue. A.P.

Waste in drying. M. W. BLAIR. *Bull. Amer. Ceram. Soc.*, **16** [9] 361–64 (1937).

PATENTS

Annealing furnace. L. C. HAMLINK (Gas Machinery Co.). U. S. 2,091,979, Sept. 7, 1937 (June 6, 1935).

Apparatus for making ceramic articles. A. H. FESSLER AND RALSTON RUSSELL, JR. (General Motors Corp.). U. S. 2,091,973, Sept. 7, 1937 (June 27, 1935). A press for molding ceramic objects, etc., comprises a mold retainer open on one side, a solid mold of yieldable material having flow characteristics under pressure confined within the retainer, having a die cavity opening on the side of the retainer, and a movable closure adapted to close the open side of the retainer and the cavity, and means for producing relative movement between the closure and the retainer to apply pressure to the yieldable material to cause it to flow into the cavity in the die.

Apparatus for manufacture of pottery. W. J. MILLER. U. S. 2,091,766, Aug. 31, 1937 (July 14, 1933).

Automatic machine for direct printing on cylindrical objects especially tubes and glass bulbs. J. P. P. DOMBRE. Brit. 470,692, Sept. 1, 1937 (March 4, 1937).

(A) Charging of, (B) discharging materials from, high-speed rotary furnaces. G. ZOTOS. Brit. 464,784 and 464,785, Oct. 24, 1935; *Brit. Chem. Abs.-B*, **56**, 629 (July, 1937).—(A) In a centrifugal furnace for whirling glass, silicates, etc., the melt is poured in evenly over the length at a descending point of the circle. (B) A skimmer is described.

Continuous clay cutters. T. KOIDL. Brit. 469,523, Aug. 11, 1937 (Sept. 2, 1935).

Control of furnace temperature. R. L. MELTON (Carborundum Co.). U. S. 2,090,692, Aug. 24, 1937 (Dec. 28, 1934).

Drying ceramic products. JEAN B. MONNIER. Fr. 796,865, April 16, 1936; *Chem. Abs.*, **30**, 6523 (1936). Ceramic products, particularly tile and brick made from clay of low capillarity and high contraction, are dried by intermittent exposure to hot air in circulation and are then submitted to an intense drying.

Drying process for ceramic building products. BOHY

FRÈRES ET CIE. Brit. 470,006, Aug. 18, 1937 (Nov. 27, 1935).

Dynamic balancing apparatus. H. W. MOORE. U. S. 2,090,803, Aug. 24, 1937 (July 13, 1933).

Excavating dipper. M. L. FYKSE (Bucyrus-Erie Co.). U. S. 2,091,974, Sept. 7, 1937 (March 16, 1936).

Filter press. E. KINSELLA AND C. W. ADDY (Henry Dreyfus). Can. 367,646, July 27, 1937 (Aug. 21, 1935). G.M.H.

Flotation separation apparatus. L. L. MAYER AND R. M. HALE (Minerals Separation North American Corp.). Can. 367,620, July 27, 1937 (Nov. 26, 1935; in U. S., Dec. 15, 1934). G.M.H.

Heating element for annealing furnaces. L. C. HAMLINK (Gas Machinery Co.). U. S. 2,091,980, Sept. 7, 1937 (June 6, 1935; April 24, 1937).

Machine for making tile, slabs, etc. J. E. AISHER (Marley Tile (Holding) Co., Ltd.). U. S. 2,090,928, Aug. 24, 1937 (Nov. 12, 1936). A pallet conveying means for machines for making tile, slabs, etc., is described.

Magnetic chain feed and separator. W. I. SALLEE. U. S. 2,092,025, Sept. 7, 1937 (June 23, 1934).

Method for making ceramic bodies. KARL SCHWARTZWALDER AND A. S. RULKA (General Motors Corp.). U. S. 2,092,027, Sept. 7, 1937 (June 27, 1935). The method of forming bodies out of substantially nonplastic ceramic material consists in grinding the material, preparing a slip therefrom, and applying pressure to a portion of the slip confined in a nonporous mold consisting of movable parts having clearance between them sufficient to permit the escape of fluid but not of the nonplastic material to force out excess water and produce a coherent body of the desired shape, the fluid in the slip serving to equalize the distribution of pressure throughout the body during the pressing operation, producing a body of substantially uniform density.

Method of making ceramic products. T. G. McDOUGAL (General Motors Corp.). U. S. 2,092,001, Sept. 7, 1937 (June 27, 1935). The method of making ceramic articles consists in pulverizing ceramic material, the major portion of which consists of nonplastics, to a grain size not larger than about 43 microns, subjecting the material to high pressure to cause the particles to form a coherent mass, and firing the mass at temperatures in excess of 1370°C to form a dense, substantially impervious article.

Method for manufacturing pottery ware. W. J. MILLER. U. S. 2,091,767, Aug. 31, 1937 (July 14, 1933; May 6, 1935).

Method of treating argillaceous substances and products thereof. H. L. KAUFFMAN. U. S. 2,091,548, Aug. 31, 1937 (Aug. 28, 1934). The improved process of treating an argillaceous substance having a low plasticity in order to increase the plasticity thereof consists in subjecting it, in a closed chamber built to withstand substantial pressure, to the action of elastic fluid comprising water-vapor, under a pressure exceeding about 200 lb./sq. in. and at a temperature exceeding 212°F, and progressively forcing the argillaceous substance out through a relatively constricted opening in the chamber while maintaining a pressure substantially above atmospheric within the chamber.

Mineral separators. WILLIAM L. ZEIGLER. Can. 359,399, July 28, 1936; *Chem. Abs.*, **30**, 6244 (1936).—Structural details are described of a mineral separator of the flotation type having an aërating chamber, with an overhead suspension for a revolving central head having radial slots at its periphery with downwardly bent vanes located between adjoining slots.

Sedimentation apparatus. W. A. KIVELL (DORR Co., Inc.). U. S. 2,092,620, Sept. 7, 1937 (Jan. 15, 1935).

Vibratory screen. C. C. FERRISS, SR. U. S. 2,091,503, Aug. 31, 1937 (July 23, 1934).

Kilns, Furnaces, Fuels, and Combustion

Analyses and softening temperatures of coal ash from coals in the northern anthracite field. DAVID J. JONES AND E. L. BULLER. *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 25–27 (1936). F.G.H.

Chemical equilibrium of gaseous phases. L. REINGOLD. *Chaleur & Ind.*, No. 195, pp. 265–78 (1936); *Jour. Soc. Glass Tech.*, **21** [83] 7A (1937).—A mathematical method for finding the flame temperature of a combustible gas mixture when burned in a known excess of air is presented; the effect of excess air and the reciprocal influence of H_2O vapor and CO_2 on the equilibrium dissociation were allowed for when calculating the flame temperature. See *Ceram. Abs.*, **15** [9] 284 (1936).

Colloidal fuel. A. B. MANNING AND R. A. A. TAYLOR. *Ind. Chemist*, **12** [134] 111–12 (1936); *Steam Engr.*, **5** [55] 265–66 (1936); *Mech. Eng.*, **58** [7] 450–51 (1936).—The name "colloidal fuel" is commonly used for coal-oil suspensions. Normally the size of the particles of coal in a coal-oil fuel ranges from 1 or 2μ to 65μ or more which is considerably above the upper limit of colloidal dimensions (0.1μ). A suspension of pulverized coal in oil will, in general, be unstable, and there will be a progressive deposition of the coal at a rate dependent on (1) the size of the coal particles, (2) the viscosity of the oil, (3) the concentration of the suspension, and (4) the specific gravities of the components. Four methods of conferring stability to the mixture are as follows: (1) reducing mechanically the particle size of the coal, (2) conferring a gel structure on the oil by incorporating in it a suitable agent, a "fixateur" or stabilizer, (3) using a peptizing agent, and (4) choosing an oil of a type that gives stable suspensions. The use of colloidal fuels has not become general, but is likely to be fully and seriously considered with the advent of higher fuel-oil prices. H.E.S. + F.G.H.

Determining ash in high-carbonate coals: modified method. O. W. REES. *Ind. Eng. Chem., Anal. Ed.*, **9** [7] 307–309 (1937).—R. describes in detail the investigation of a modified procedure, first proposed by S. W. PARR (*Ceram. Abs.*, **11** [8] 466 (1932)), for determining ash and mineral matter in coals high in pyrite and calcium carbonate. Illustrated. F.G.H.

Direct simultaneous microdetermination of carbon, hydrogen, and oxygen: IV, Analysis of bituminous coals and derived products. W. R. KIRNER. *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 57–61 (1936); for Part II see *Ceram. Abs.*, **15** [5] 167–68 (1936). F.G.H.

Electric decorating kilns. A. J. G. SMITH. *Elec. Rev.*, **121** [3114] 142 (1937).—S. discusses the relative efficiencies of different types of intermittent decorating kilns (British) heated by electricity. J.L.G.

Evaporation by submerged combustion: VI, Dewatering clay suspensions. K. A. KOBE, HEWITT WILSON, AND T. M. SHEEHY. *Jour. Amer. Ceram. Soc.*, **20** [10] 348–52 (1937).

Firing refractory brick. R. KLESPER. *Feuerungstechnik*, **25** [3] 79–83 (1937).—K. gives details of the operation of periodic furnaces and the firing of silica brick. Illustrated. M.V.C.

Graphic representation of the operation of gas generators. ROMAN DOWIDOWSKY. *Feuerungstechnik*, **25** [6] 183–95 (1937).—Various stages of gas generation are graphically presented, and the use of these graphs is explained. M.V.C.

Insulation of ceramic kilns. B. HELAN. *Zprávy Československ. Keram. Společnosti*, **11**, 5–12 (1934); *Chem. Zentr.*, **1935, ii**, 2995; *Brit. Chem. Abs.-B*, **56**, 544 (June, 1937).—The use of heat-insulating materials is discussed.

Modified capillary combustion unit for a gas-analysis apparatus. BERT E. CHRISTENSEN AND ROBERT CARLTON. *Ind. Eng. Chem., Anal. Ed.*, **9** [8] 400–401 (1937).—The modified capillary combustion pipet offers a safe, precise, and convenient method for the analysis of combustible gases (except acetylene). The unit can be easily incorporated into the standard gas-analysis apparatus. A simple method is given for preventing the propagation of flames through capillary tubing. Illustrated. F.G.H.

Pulverized-fuel firing without a pulverizer. H. D. TOLLEMACHE. *Foundry Trade Jour.*, **54** [1014] 85–87 (1936).—The advantages of pulverized-fuel firing are pointed out. The purchase of pulverized fuel of standard value is urged for the following reasons: (1) the grinding plant and its capital investment and operation may be dispensed with; (2) the correct type of raw material is selected by the producer; and (3) the proper grinding with uniform consistency and quality is maintained by the producer. The method of production and transportation is well illustrated. Pulverized fuel is being used in all operations where gas and oil are used. It is especially adaptable for metallurgical work where furnace atmosphere control is important as well as temperature control. H.E.S.

Thermodynamic properties of methane. W. C. EDMISTER. *Ind. Eng. Chem.*, **28** [9] 1112–16 (1936).—Specific heats at constant pressure, differences in specific heats, Joule-Thomson coefficients, entropy, and enthalpy are computed for methane for pressures of 1 to 120 atm. and for temperatures of −70° to 200°C. This work is based on the *P-V-T* data of Kvalnes and Gaddy and of Keyes and Burks and on the specific heat at constant-pressure data at 1 atmosphere of Eucken and Lude. Data on these thermodynamic properties are presented, and from them the specific volume, internal energy, Gibbs free energy, and Helmholtz free energy may be calculated also. Plots of the volume residual, α *vs.* T isobars, C_p *vs.* T isobars, $C_p - C_v$ *vs.* T isobars, and the Joule-Thomson coefficient, μ *vs.* T isobars, are also presented. Illustrated. F.G.H.

BOOKS

Analyses of Coals and Other Solid Fuels, 1934 to 1936. J. H. H. NICOLLS AND C. B. MOHR. *Can. Dept. Mines, Bur. Mines, Mines & Geol. Branch, Dept. Mines & Natural Resources, Pub.*, No. 779, 139 pp. (1937). Price 25¢. G.M.H.

Change in electrical resistance of silicon carbide resistors during service. WILHELM MEYER. *Mitt. Forsch.-Inst. Elektrowärmetech., Tech. Hochschule Hannover*, No. 17 [Part 8, Schriftenfolge Elektrowärme] 52 pp. (1937); *Chem. Abs.*, **31**, 2935 (1937).—Tests were carried out at 1400°, the maximum recommended by the manufacturers of Globar and Silit resistor units. Operation in the open air resulted in the formation of SiO_2 on the surface of the crystals as well as at the interfaces. No recrystallization and grain growth could be detected. Results of tests in A were very much the same as those in air, *i.e.*, vaporization of Si, SiO_2, etc., with consequent increase in resistance. No two SiC rods gave identical time *vs.* resistance curves. After 600 hours at 1400° the range of resistance change was between 37 and 90% for one manufacturer's product. Tests were also carried out inside a resistor furnace, (*a*) with current and (*b*) without current passing through the rod. Intermittent service resulted in shorter total operating life. The abrupt changes in resistance after cooling are attributed to the formation of β-cristobalite (transition temperature 200° to 250°). If the rods are not allowed to cool below 350°, no abrupt changes in resistance occur.

Electric Furnaces (Elektrische Ofen). Parts IV–VI of Vol. I of Advances in Chemical Plant (Fortschritte des chemischen Apparatewesens). Edited by H. ALTERTHUM. Akademische Verlagsges.m.b.H., Leipzig, 1936. 938 pp. Price 172 M, 28 M per part. Reviewed in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 97, p. 31 (1937).—The finished volume covers all aspects of electric furnaces and their uses. Each section of the subject is briefly surveyed from the standpoint of present knowledge and German patent literature; then follows a list of German patents bearing on the subject discussed. This part of the volume occupies 236 pages. The second part (656 pages) gives a list of all German patents on electric furnaces and related matters in numerical order, with an abstract of the contents of each (in some instances references to corresponding foreign patents are given). Finally, United States and British patents are dealt with, but more briefly, being set out by number only in the appropriate sub-classes of the American and British patent classifications. The survey of German patents extends to the end of 1931. The volume is of interest to all who are concerned with any aspect of electric furnaces or their uses, whether for metallurgical or other purposes. See *Ceram. Abs.*, **15** [4] 130 (1936).

PATENTS

Charging brick kilns. KARL HAUER. Ger. 623,858, Jan. 6, 1936; Cl. 80*c*. 16.01; *Chem. Abs.*, **30**, 5010 (1936).

Firing ceramic ware. PORZELLANFABRIK KAHLA (Friedrich Dettmer, inventor). Ger. 623,993, Jan. 9, 1936; Cl. 80*b*. 12.16; *Chem. Abs.*, **30**, 5010 (1936). Porcelain and other things are fired in an electric furnace at temperatures above the decomposition point of Fe_2O_3, *i.e.*, 950°, with introduction of pure CO as reducing gas.

Muffle construction. H. M. ROBERTSON (Electro Refractories & Alloys Corp.). U. S. 2,093,212, Sept. 14, 1937 (Oct. 31, 1935). In a muffle adapted to be incorporated substantially vertically with the walls of a kiln and coöperate therewith to form a combustion chamber, the muffle comprises spaced inner and outer walls corrugated on vertical lines, the corrugations being related so as to dispose all portions of the walls in parallel relation, end walls integral with the inner and outer walls, and transverse webs formed integrally with and connecting the inner and outer walls and uniformly spaced from the end walls and each other, the end walls and webs extending from the bottom to the top of the outer wall.

Tunnel kiln for salt-glazing pottery. HEIMSOTH-VOLLMER-DRESSLER G.M.B.H. Ger. 625,559, Feb. 24, 1936; Cl. 80*c*. 8; *Chem. Abs.*, **30**, 5010 (1936).

Geology

Action of substances having a hydrophobic and a gel-forming effect on clays. V. S. SHAROV. *Groznenskiĭ Neftyanik*, **6** [3] 10–15 (1936); *Chem. Abs.*, **31**, 2764 (1937).—Dry bentonite clay placed in 1.5 and 10% solutions of tannin swelled rapidly and disintegrated into lumps. After 3 days the disintegrated lumps showed 960% H_2O in H_2O, 665% H_2O in a 1% solution of tannin, 317% in a 5% solution, and 164% in a 10% solution. The action of tannin is due to (1) the appearance of a polar active group on the clay surface which for tannin is represented by a glucose group, C_6H_7O, and (2) the apolar inactive group represented by a long aromatic chain in tannin. The first group represents the bipolar H_2O molecules and is therefore called the hydrophylic group. The second group is inert to H_2O and is therefore called the hydrophobic group. When clay comes into contact with an aqueous tannin solution the hydrophylic ends of the molecules of tannin are attracted by the surface layer of the clay, while the hydrophobic ends are repulsed. Such an attraction is explained by the presence of free charges at the exposed anions and the absorbed cations of the clay particles. On the surface of the clay is formed a "brush" of hydrophobic ends of the tannin molecules. At a suitable concentration of the tannin this "brush" creates a wall preventing the penetration of H_2O into the clay. The disintegration of the bentonite clay in solutions of salts is explained by a lowering in hydration accompanied by an increase in the velocity of hydration. The effect of hydration depends upon the concentration of tannin and also the coarseness of the clay. The clay structure becomes of secondary importance for high tannin concentrations. Among the gel-forming substances are gelatin, glue, starch, and Na silicate. They are absorbed into the crevices of the clay surface, thereby dehydrating the sol, converting it into the gel, and preventing the admission of H_2O. These substances prevent the hydration of dry Na clays and of highly dispersed clays.

Asymmetry and orientation of clayey micellae. ST. HÉNIN. *Compt. Rend.*, **204** [20] 1498–99 (1937).—A study of clay in different suspensions and under the influence of different mechanical or electrical forces has shown that the clayey micella must be assumed to be geometrically and electrically asymmetric. Oriented deposits were formed by desiccation, and the strong cohesion when they are rehumidified is due to electrical charges or chemical functions between the micellae. Five references. M.H.

Base-exchange capacity and clay content of soils. R. L. MITCHELL AND ALEX. MUIR. *Nature*, **139** [3517] 552 (1937).—The generally accepted range for base-exchange capacity of mineral soil colloids is 0.5 to 1.0 milligram equivalents per gram. These values, however, are dependent on particle size and distribution. Chemical composition, the SiO_2:R_2O_3 ratio in particular, is important in determining adsorption capacity. The authors investigated the exchange capacity of soil profiles on basic igneous parent materials, using the Parker method.

Soil	SiO_2/Al_2O_3	Clay content	Exchange capacity	Mg. equiv./g. of clay
4792	1.55	16.0	35.2 (32.9)	2.2
5048	3.83	11.6	42.5 (43.0)	3.7
5044	4.05	10.7	41.8 (39.0)	3.9
4784	5.95	9.8	42.1 (38.9)	4.3
5001A	8.40	15.7	88.0 (98.6)	5.6
5002	2.16	3.8	34.8 (29.6)	9.1

Figures in parentheses are sums of individual exchangeable cations. Except for the last sample, there is an approximate linear relationship between SiO_2:Al_2O_3 ratio and exchange capacity per gram of clay (less than 2 micron particles). This indicates that soils with very high exchange powers relative to clay content do exist and that care should be taken not to apply clay exchange-capacity factors to soils for which they are not valid. J.L.G.

Bauxites of the northern Urals and the problems of their investigation. E. MOLDOVANTZEV. *Trans. Central Geol. Prospecting Inst.*, **24**, 1–52 (1934); *Neues Jahrb. Mineral. Geol.*, Referate II, pp. 185–87 (1936); *Chem. Abs.*, **30**, 8094 (1936).—Al_2O_3 in Ural bauxite occurs as a monohydrate gel, $Al_2O_3 \cdot H_2O$, and as crystalline diaspore; SiO_2 occurs as a gel (about $1SiO_2$:$1H_2O$); the average TiO_2 content is about 2.5%; $CaCO_3$ is seldom over 1%; the S content of red-brown bauxite is small (up to 0.4%). Numerous bauxite analyses are given.

Changes in the structure of Central Asian clays during peptization. B. G. ZAPROMETOV, L. B. SMOLINA, AND A. SHAMSIEV. *Kolloid. Zhur.*, **2**, 1–15 (1936); *Chem. Abs.*, **30**, 5378 (1936).—Treatment with solutions of *N*/100 $Na_4C_4H_4O_8$ + *N*/500 NaOH changes the speed of filtration fusion point and plasticity of various Central Asian clays due to peptization of the clay particles. Complete analyses are given; SiO_2 varies from 54 to 74, R_2O_3 19 to 32, and Fe_2O_3 2.4 to 8.1%. The peptization effect passes through a maximum and then decreases with greater additions of peptizing solution.

Chromite deposits in the Urals. A. S. VAKHROMEEV, I. A. ZIMIN, K. E. KOZHEVNIKOV, A. N. LAS'KOV, AND G. M. MAZAEV. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Mineral. Syr'ya*, No. 85, pp. 1–240 (in English 236) (1936); *Chem. Abs.*, **31**, 3831 (1937).—The chromite deposits of 16 regions are described. They are genetically associated with plutonic bodies of dunite, peridotite, gabbro, pyroxenite,

and their serpentinized equivalents, intruded during the Hercynian folding. The deposits are confined to the border zones of the bodies of the most ultrabasic rocks, the largest being connected with lines of fracturing. The chromite occurs in stock-like masses, lenses or successions of lenses connected by thin stringers, and plunging pipe-shaped masses; its largest deposits are disk-like or lenticular. Deposits containing 1000 to 3000 cu.m. are not common, and those of 25,000 cu.m. are very rare. Some deposits consist almost entirely of the ore; others are of the disseminated type. As to genesis, different deposits are classified as (1) accumulative, formed by crystallization differentiation and concentration of the ore minerals by pressure, molecular diffusion, and convection currents at the borders of igneous bodies; (2) liquation, formed by the separation of an ore-mineral liquid phase, which was subsequently intruded along fractures; and (3) intermediate, formed by crystallization of chromite, its accumulation in viscous or plastic silicate material, followed by intrusion of the viscous mass along fractures, giving banded disseminated ores. Analyses of 148 samples of ores and concentrates and estimates of tonnages of ores of different classes containing 30 to 55% Cr_2O_3 are given. Analyses of ore minerals plotted on a square diagram whose corners represent $FeO{\cdot}Al_2O_3$ (hercynite), $MgO{\cdot}Al_2O_3$ (picotite), $MgO{\cdot}Cr_2O_3$ (picrochromite), and $FeO{\cdot}Cr_2O_3$ (chromite) show that the most common minerals are varieties of alumino-chrompicotite, representative of the ores of intermediate quality. The varieties chrompicotite and berezovite, representative of high-grade ores acceptable for the manufacturing of ferrochrome, are not as widespread.

Clay minerals in coal measures. T. Deans. *Trans. Leeds Geol. Assn.*, **5** [3] 161–87 (1936); abstracted in *Science Progress*, **31**, 701 (1937).—Ironstones from the coal measures of Yorkshire are characterized by the occurrence of oölitic clay minerals along with siderite. They have been formed by precipitation of siderite and hydrous aluminum silicates, with subsequent replacement and crystallization. H.H.S.

Determination of the mineral content of soil colloids. Emil Truog. *Amer. Soil Survey Assn., Rept. 16th Ann. Meeting, Bull.*, No. 17, p. 20 (1936); *Chem. Abs.*, **30**, 5342 (1936).—Longer treatment with H_2S is recommended for soils high in free Fe oxides. Redefinition of the upper limit of particle size of soil colloids to be identical with the clay fraction is recommended.

Experimental study of the plasticity of clays. Henry Cassan and André Jourdain. *Céramique*, **40** [592] 117–26 (1937).—An apparatus for determining the flow of a slip under constant pressure with a varied ratio of water to clay has been devised. A comparison of different clays treated identically showed that the pressure necessary to start the flow is varied; the results of these determinations showed that they are exact and that the classification of clays made by this method corresponds to empirical classifications determined by other methods. The curves resulting from these experiments were plotted as a function of the ratio of water to clay (ordinates) and the pressure necessary to start the flow (abscissas). These curves are similar and permit the classification of clays according to their plasticity. A physicomathematical interpretation of the curves is given. M.V.C.

Feldspar deposits of U.S.S.R. D. S. Belyankin and B. V. Ivanov. *Keram. & Steklo*, **13** [4–5] 40–45 (1937).—A brief discussion is given of mineral deposits of Russia containing various types of feldspar used in the ceramic industry. M.V.C.

Heterogeneity of parent magma. J. S. DeLury. *Jour. Geol.*, **45** [4] 381–90 (1937).—Diversity in composition of igneous rocks is commonly considered due to the dominance of differentiation processes over assimilation. DeL. ascribes a major part to assimilation. He postulates that most magma is "generated by frictional heat during wide and forceful migration" and thus is strongly affected by its more or less heterogeneous environment. Mass diversity thus results chiefly from heterogeneity of parent magma rather than differentiation in homogeneous magma chambers. A.B.

Investigation on clays. Carl W. Correns. *Sitzber. Abhandl. Naturforsch. Ges. Rostock*, [3] **4**, 30–35 (1932–34); *Chem. Abs.*, **31**, 3652 (1937).—The particle-size composition of clays can be determined by various methods without great differences in the results.

Kaolin and clay. W. L. de Keyser. *Natuurw. Tijdschr.*, **19**, 91–105 (1937); *Chem. Abs.*, **31**, 5964 (1937).—Zettlitz kaolin was heated in a 10 x 30 mm. cylindrical Cu boat with a thermocouple placed inside a quartz tube closed at one end. The heating element was nichrome wire. All was suspended in a 5-liter bottle and evacuated. The bottom of the bottle was covered with P_2O_5. The kaolin was periodically weighed. The total ignition loss was 15.1%, but even at 300° 1% loss was found after 200 hr. at 350°; 4% loss after 24 hr. The decomposition temperature of kaolin is, therefore, below 350°. Further thermal analyses were made in the Le Chatelier-Saladin apparatus (H. A. J. Pieters, *Ceram. Abs.*, **8** [3] 224 (1929)) by using standard and test substances in semicylindrical shape, forming together a cylinder coaxial with the furnace, each half having its own thermocouple. For substances which can not be formed into cylinders, the heating was done in a kaolin crucible previously heated to 1200° and placed in stainless steel. Dehydration curves indicate that regardless of an initial heating period of 0.5, 1.5, or 4 hours, the dehydration of kaolin does not begin below 500°, because the time factor is too short. The results with Zettlitz and with "Les Eyzies" (French) kaolin are the same. The sensitivity of the method does not allow a heating period of more than 10 hours from 20° to 1000°. Efforts to reproduce the reaction in dehydrated kaolin found by Satoh at 650° were fruitless and it is assumed that the Azusheniomura kaolin contained dickite.

Kaolinites susceptible to activation. J. de Lapparent. *Compt. Rend.*, **204** [12] 937–39 (1937). M.H.

Mineralogical nature of the clays of El Golea (Sahara). J. de Lapparent. *Compt. Rend.*, **204** [24] 1776–78 (1937).—L. describes geological and stratigraphic conditions of the deposits which conform to the composition formula, measured with Debye's radiograms,

$$\left\{ \begin{matrix} (OH)_2{\cdot}Al_{1.5}Mg_{0.4}H_{0.7}{\cdot}Si_3H_{3.3}O_{10}, \textit{ i.e.,} \\ K_{0.5} \end{matrix} \right.$$

analogous to phyllite and bravaisite. M.H.

Saskatchewan bentonites. W. G. Worcester. *Can. Mining & Met. Bull.*, No. 304, pp. 438–51 (1937).—Notes

on general characteristics, origin, geological occurrence, history of development, and uses are given. Very little bentonite is produced in Canada. Import statistics are indefinite, but imports are known to be considerable and the potential Canadian market large. There are large, easily accessible deposits in Saskatchewan. W. has investigated Canadian bentonites since 1918; since 1932 at the University of Saskatchewan he has worked on bentonites of that province. Particularly in the Knollys area are bentonites which, raw, show high decolorizing properties on vegetable oils and, activated, on mineral oils. Optimum activation conditions for each clay tested have been developed. Farther east, around Twelvemile Lake, are bentonites of somewhat different character; laboratory work indicates their suitability for such purposes as bond in molding sands. Bentonite is used at the University of Saskatchewan to replace kaolin or ball clay in certain colored glazes, with the effect of increasing the gloss. G.M.H.

Secrets of zirconium. R. Brouns. *Deut. Goldschmiede-Ztg.*, **40**, 63–64 (1937); abstracted in *Chem. Zentr.*, **1937**, **i**, 4760.—The effect of radium on colorless zirconium was studied. There are three kinds of colorless zircons: (1) originally brown (hyacinth), which loses its color at 500°; (2) the primarily pink-red (in druses), which becomes colorless or gray under the effect of sunlight; and (3) naturally colorless zircons. The zircons of the first group become colored again under the effect of radium; those of the second group become pink-red, then brown; no green, blue, or violet colors of other natural zircons appear. The third group does not react with radium. It must be assumed that zircon itself is radioactive because of the presence of small amounts of thorium and mesothorium in it. It must also be assumed that highly dispersed pigments are present in zircons, iron and manganese compounds in hyacinths and probably Mn in blue zircons. M.V.C.

Selenium ore deposit at Pacajake, Bolivia. H. Block and F. Ahlfeld. *Z. Prakt. Geol.*, **45**, 9–14 (1937); *Chem. Abs.*, **31**, 3423 (1937).—The vein consists mostly of blockite ($(NiCu)Se_2$) and clausthalite. Native Se has also been found. Chalcomenite ($CuO{\cdot}SeO_2{\cdot}2H_2O$) has been determined among six other Se minerals. Siderite, hematite, barite, and calcite also are present.

Source of gypsum in Nova Scotia. Victoria Gypsum Co., Ltd. *Ind. Chemist*, **12** [143] 552 (1936).—An important new source of gypsum has been made available by the construction of a plant in Cape Breton, Nova Scotia. The property is about 800 acres in extent and is covered practically throughout by a deep bed of gypsum with very little overburden. The rock is reduced by a primary crusher to $4^1/_2$ in. cubes and by a secondary crusher to 2 in. cubes. The crushed material is conveyed, by a belt conveyer to accommodate the contour of the land, to storage near the dock. The conveyer is 2500 ft. long. The plant has a capacity of crushing and storing rock at 400 tons/hr. H.E.S.

Technological tests of disthene-corundum ore of the Tchainyt deposit. A. S. Bazilevich. *Mineral. Syr'e*, **11** [1] 30–33 (1936); abstracted in *Chimie & Industrie*, **37** [2] 302 (1937).—The samples analyzed contained 53–59% alumina with impurities. Refractoriness was only 1725° to 1775°C because of the large amount of fusible oxides (mica, rutile, etc.). Mechanical and thermal resistance and physical constants proved satisfactory. M.V.C.

Totin bauxite deposit. G. K. Volosyuk. *Razvedka Nedr.*, No. 1, pp. 17–20 (1937); *Chem. Abs.*, **31**, 3423 (1937).—A number of samples drawn from the Totin, Southern Ural, bauxite deposit showed the composition SiO_2 3.17 to 10.69, TiO_2 3.20 to 3.84, Al_2O_3 47.60 to 55.87, and Fe_2O_3 22.29 to 25.51%.

Ural deposits of kyanite. A. N. Igumov and K. E. Kozhevnikov. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Mineral. Syr'ya*, No. 90, pp. 3–68 (in English 69–75) (1935); *Chem. Abs.*, **31**, 3832 (1937).—Twenty kyanite deposits are mentioned and four are described in detail. The kyanite occurs as disseminated crystals in lenses of mica schist, which are part of more extensive schist areas cut by granites and pegmatites. Analyses of 11 samples of crystals, numerous analyses of concentrates, and estimates of tonnages of kyanite available are given. Refractory brick have been made from semi-concentrates, and good-quality laboratory ware and spark plugs have been made from concentrates.

BOOKS AND BULLETINS

Canadian Mineral Industry in 1936. Anon. *Can. Dept. Mines, Bur. Mines, Mines & Geol. Branch, Dept. Mines & Natural Resources, Pub.*, No. 786, 78 pp. (1937). Price 25¢. Notes on the mineral industries of Canada are given under 61 headings. G.M.Hutt

Electrometallurgical investigations. *U. S. Bur. Mines Repts. Investigations*, No. 3322. 64 pp. Free. The report includes "Studies on the treatment of domestic chrome ores," by J. Koster; "Electrolysis of manganese solutions," by S. M. Shelton; and "Electrometallurgical studies on the treatment of alunite," by R. G. Knickerbocker and J. Koster. It is in the nature of a progress report of the work of the Electrometallurgical Section for the fiscal year 1936. R.A.Heindl

Non-Metallic Mineral Resources of New Mexico and Their Economic Features (Exclusive of Fuels). S. B. Talmage and T. P. Wootton. *N. Mex. School Mines Bull.*, No. 12 (1937). 159 pp., 1 map. Price 50¢ The description, uses, and occurrences of clays, bentonite, and other minerals of value to the ceramic industry are given. R.F.Rea

Introduction to the Scientific Study of the Soil. N. M. Comber. E. Arnold, London, 1936. 3rd ed. vii + 206 pp. Price 7s 6d. Reviewed in *Chem. & Ind.*, **56** [18] 408 (1937). —C.'s well-known book, which has deservedly reached a third edition, might perhaps have been more correctly entitled "a scientific introduction to the study of the soil." The study of the soil, as most agricultural students (for whom the book is written) know it, is essentially practical, whereas the scientific study of the soil, pedology, is remote from agriculture. It is, indeed, possible to understand pedology without knowing that farming and fertilizers exist, and it is equally possible to "do" agricultural soil science without any knowledge of pedology, but both the agriculturist and the pedologist need to know a good deal about the intermediate link between them, comprised in the chemistry and physics of the soil. It is with this all-important link that the book is mainly concerned, with a strong bias toward the agricultural side. It is, however,

a "scientific" introduction in that the scientific point of view is never lost, and the soil is depicted as an organic entity which can, with caution, sometimes be modified to man's advantage.

This book has been brought fully up to date, but no outstanding changes have been made in the third edition. The lucidity with which the main facts about soil water are described, necessarily in the barest outline, makes this section of the book an admirable introduction to more erudite works in which the simple original meaning of strangely sounding terms is often hidden in a mass of technicalities. The same can be said of most of the other chapters. The customary small amount of space is devoted to humus, the one substance whose reactions really matter in pedology, but of which our scanty knowledge is useless to agriculture. There is a useful chapter on what to read in scientific literature, but one misses in the book itself any references to the sources of quoted works. Neither the student nor the advanced worker should be encouraged in the facile tendency to accept a statement in a textbook, however good, at its face value.

PATENT

Purifying clay. ENGLISH CLAYS, LOVERING, POCHIN & CO., LTD. Fr. 792,256, Dec. 26, 1935; *Chem. Abs.*, **30**, 4289 (1936). Clay is mixed with either a dilute aqueous solution of sulfite lye or a dilute aqueous solution containing a sulfite lye and an alkaline electrolyte, such as NaOH or Na_2CO_3, and is afterward precipitated by adding an appropriate precipitating agent such as a mineral acid or alum.

Chemistry and Physics

Analysis of pollucite. ROGER C. WELLS AND ROLLIN E. STEVENS. *Ind. Eng. Chem., Anal. Ed.*, 9 [5] 236–37 (1937).—The Wells and Stevens' method for the determination of rare alkalis, as applied to the analysis of pollucite, a mineral of high cesium content, is described in detail. F.G.H.

Arsenate method for the determination of zirconium. WALTER C. SCHUMB AND EDWARD J. NOLAN. *Ind. Eng. Chem., Anal. Ed.*, 9 [8] 371–73 (1937).—For the decomposition of zirconium ores in general, sodium carbonate fusion followed by potassium pyrosulfate fusion is recommended. A proposed method of analysis for zirconium in solutions and ores is described in detail. Zirconium forms a difficultly soluble precipitate with ammonium arsenate. The precipitate is bulky, flocculent, and easily filtered if an excess of arsenate is used; its composition corresponds to that of the normal arsenate, $Zr_3(AsO_4)_4$, highly hydrated and containing some adsorbed ammonium arsenate. The precipitate may be ignited directly to ZrO_2 by the use of forced reducing conditions in ashing and igniting; without this precaution arsenic is retained to a variable extent. F.G.H.

Chemical constitution as related to the physical properties of the clays. C. E. MARSHALL. *Trans. Ceram. Soc.*, **35** [9] 401–11 (1936).—Several soils and a bentonite were fractionated according to particle size, and the subfractions less than 0.5μ in equivalent diameter were examined by means of X-rays. The structure of the finer fractions was found to be of the montmorillonite type, since it showed expansion of the lattice layers with increasing water content, whereas their physical and chemical properties agreed with those of beidellite. By comparing analyses and assuming the following substitutions to operate, (1) 3 Mg for 2 Al in hydrated alumina layers, (2) Al + a cation for Si in silica layers, (3) Fe for Al in hydrated alumina layers, M. found that analyses of montmorillonite and beidellite agreed on the 2:1 type lattice structure and that the minerals montmorillonite, beidellite, and nontronite are members of an isomorphous series. Reasons for the occurrence of the clay minerals principally as crystals of colloidal dimensions are considered. In the kaolin series, it is due to a distortion or strain in the lattice, but in the montmorillonite group it is more closely associated with crystal habit and oriented coagulation of the plate-shaped particles, the mechanism of which is explained by a consideration of the base-exchange properties of the clays. Exchangeable cations distributed between lattice layers tend to hold charged layers together. Only a slight increase in total exchange capacity is to be expected with increasing dispersion, but the exchange capacity may be very sensitive to changes in total composition. New conceptions of clay structures make possible the more precise interpretation of dehydration curves. It is suggested that work be done using vapor pressure as well as moisture content and temperature as variables. R.H.H.P., JR.

Chemistry of the Chinese copper-red glazes: I. J. W. MELLOR. *Trans. Ceram. Soc.*, **35** [8] 364–78 (1936).—The Chinese copper-red in-glazes utilize as a tinctorial agent colloidal metallic copper derived from copper oxide, contain tin oxide or an equivalent (iron oxide), are fired in a reducing atmosphere, and are finished off in an oxidizing atmosphere. Passing downward from the surface of the glaze, five differently colored layers can be distinguished in a microscopic section: (1) a colorless or very faint green layer containing cupric silicate in solution formed by the oxidation of colloidal copper in the red layer, (2) a yellow layer, frequently absent, representing an arrested stage in the oxidation of colloidal copper, (3) a red layer containing colloidal copper precipitated in association with stannic oxide or iron oxide as a protective colloid, (4) a blue layer representing a transition stage in the separation of colloidal metallic copper from the solution of copper or a lower oxide in the glaze, and (5) a grayish, almost colorless layer next to the body containing copper or cuprous oxide in solution. The case for cuprous oxide as the tinctorial agent in the flambé glazes is disproved. It is shown that stannous oxide in the lowermost reduced layer is converted by aërial oxygen diffusing toward the body from the surface of the heated glaze into stannic oxide which promotes the passage of dissolved copper into the colloidal state by a reaction between stannous oxide and cuprous oxide. The colloidal copper first appears as a bluish band, and, as the stannic oxide accumulates, it is completely dispersed and then appears as a red film. When the concentration of dissolved oxygen is great enough, the collodial copper itself is oxidized. On-glaze rouge flambé effects are produced by the deposition of a surface film of colloidal copper, condensed as an aërosol from the vapor state,

which is subsequently absorbed at the surface of the glaze. Uniform deposits can be obtained by painting a mixture of a copper salt and clay upon the ware and subsequently firing in a reducing atmosphere. The diffusion of oxygen below the surface of the glassy silicates can readily be demonstrated by refiring an on-glaze flambé in an oxidizing atmosphere, whereupon a white glaze with a green surface tinge is produced. Opalescent effects are due to an incipient vitrification of the glaze because of a shortage of alumina or to the separation of stannic oxide upon cooling. The gas bubbles located in Chinese flambé glazes near the body were probably produced in the vitreous body owing to the corrosive action of the glaze. II. *Ibid.*, [11] 487–91.—The opalescent effect which more exactly refers to incipient crystallization or devitrification is often identified on Chinese-red glazes as a milkiness and should not be confused with the peach-bloom effect. The peach-bloom effect appears as small patches of copper red sprinkled over a differently colored background. In this effect the process of oxidation of the copper red is almost completed, and the particles of red which appear in the last stages of the oxidation are indicative of differences in the rates of oxidation in different parts of the same glaze. A section shows that the copper is nearly all oxidized and that the yellow color of the glaze *en masse* is due to the oxidation of the iron oxide dissolved in the glaze to the ferric state. Green particles sometimes associated with the peach bloom effect are produced by the oxidation of spots of metallic copper formed by the flocculation of the red colloidal metal. Illustrated with color plates.

R.H.H.P., Jr.

Crystal structure of barium antimonate. J. Beintema. *Proc. Acad. Sci. Amsterdam*, 39, 652–61 (1936); *Chem. Abs.*, 30, 6259 (1936).—Prepared by a diffusion method, crystals of $Ba(SbO_3)_2 \cdot 8H_2O$, or better $Ba[Sb(OH)_6]_2 \cdot 2H_2O$, are monoclinic c-axis prisms, usually twinned, with $a:b:c = 0.7965 : 1 : 0.8099$, $\beta = 87°17'$. The optical character is negative with principal n_s 1.58, 1.59, 1.60, and with $X = b$, $Y \wedge c = 16°$ in obtuse β. The axial lengths, a, b, c, are 9.961, 12.506, 10.129 Å; with $Z = 4$, the calculated density is 3.252, while density observed is 3.22. The lattice is body-centered, the space group C_{2h}^6. Possible methods of packing are discussed.

Determination of barium, sulfur, and sulfates, a rapid and accurate volumetric method. Stephen J. Kochor. *Ind. Eng. Chem., Anal. Ed.*, 9 [7] 331–33 (1937).—The present method coördinates various well-known analytical procedures. It is based on the fact that the presence of a few ten-millionths of a gram of Ba^{++} ion can be definitely detected by means of a spot reaction on filter paper with a solution of oxybenzoquinone derivatives. By using standard solutions of varying normalities a desired accuracy can be very easily obtained in all practical determinations. F.G.H.

Determination of carbon and hydrogen. An electrically heated, thermostatically controlled constant-temperature device for the Pregl C-H determination. Frank Schneider and H. L. Van Mater. *Ind. Eng. Chem., Anal. Ed.*, 9 [6] 295 (1937).—Illustrated. F.G.H.

Determination of chromium, vanadium, and molybdenum in silicate rocks. E. B. Sandell. *Ind. Eng. Chem., Anal. Ed.*, 8 [5] 336–41 (1936).—A colorimetric method is described for the determination of chromium, vanadium, and molybdenum in silicate rocks in amounts as small as 0.001, 0.001, and 0.0001%, respectively, all in a 1-g. sample which is decomposed in the usual way with sodium carbonate. Vanadium is determined with phosphotungstic acid after separation from chromium with 8-hydroxyquinoline; in neutral or slightly acid solutions, quinquevalent vanadium reacts with 8-hydroxyquinoline to give a compound that can be extracted from the aqueous solution with chloroform, whereas sexivalent chromium does not react and remains in the aqueous layer. Diphenylcarbazide is used as reagent for chromium, after the separation of the element from vanadium. Molybdenum is determined by the stannous chloride-thiocyanate-ether method without previous separation from the other constituents of the filtered leach of the sodium carbonate melt. F.G.H.

Determination of the common and rare alkalis. John C. Hillyer. *Ind. Eng. Chem., Anal. Ed.*, 9 [5] 236 (1937).—The Wells and Stevens (*Ceram. Abs.*, 14 [10] 260 (1935)) method of determining rare alkalis in minerals is discussed. H. describes revisions which are essential when minerals of high rare-alkali content are analyzed. F.G.H.

Determination of magnesium in glass with oxyquinoline. M. Lobunetz. *Univ. Etat Kiev, Bull. Sci., Rec. chim.*, 1 [4] 167–74 (1935); abstracted in *Chem. Zentr.*, 1937, i, 4413.—Glass (1 or 2 g.) is treated with soda; the SiO_2 is filtered after steaming with HCl; Na tartrate in amount of 4 to 5 g. and 1 drop of phenolphthalein are added; a 2 *N* NaOH solution is added until pink coloring appears, after which the solution is treated with a small surplus of diluted (1:1) HCl; NH_3 is added and the solution is brought to boiling; boiling Na oxalate is added for the precipitation of Ca. To the cold solution, 15 cc. of 2 *N* NaOH, to which 5 cc. of 4% alcoholic oxyquinoline solution were admixed, are added; it is heated to 60°, cooled, and filtered with the Schott crucible; after repeated washing with a 1% Na tartrate solution in 0.2 *N* NaOH and ammoniacal alcohol and water, the solution is dissolved in 2 *N* HCl; it is cooled and treated with 1 g. KBr and 2 drops of 1% indigo carmine; it is titrated with bromate until a yellow coloring appears; more bromate is added in surplus; after adding KI it is titrated back with Na_2SO_3. M.V.C.

Determination of primary calcium phosphate in mixtures of the calcium orthophosphates. H. V. Tartar, Isabel S. Colman, and Luella L. Kretchmar. *Ind. Eng. Chem., Anal. Ed.*, 9 [8] 384–86 (1937).—A new and accurate method for the determination of primary calcium phosphate in mixtures of the calcium orthophosphates is presented, in which the primary salt is determined by titrating to a p_H of 5.15 with 0.2 *N* sodium hydroxide solution. Illustrated. F.G.H.

Determination of small quantities of oxygen in gases and liquids. I. J. W. MacHattie and J. E. Maconachie. *Ind. Eng. Chem., Anal. Ed.*, 9 [8] 364–66 (1937).—Illustrated. F.G.H.

Determination of sodium in high aluminous material. H. V. Churchill, R. W. Bridges, and A. Logan Miller. *Ind. Eng. Chem., Anal. Ed.*, 8 [5] 348–49 (1936).—Aluminous materials of a refractory nature, such as calcined alumina, are treated with hydrofluoric and ammonium hydroxide in order to form ammonium fluoride *in situ*. The

latter renders the sample amenable to solution in sulfuric acid. The sodium in the form of the sulfate is then precipitated by means of uranyl zinc acetate reagent. The sodium content is determined by reducing the equivalent uranium salt to a valence of four by means of a coil of aluminum wire and titrating to the valence of six by means of standard permanganate solution. Illustrated.

F.G.H.

Estimation of potassium in silicates and soils. Low-melting alkali carbonate flux. J. E. GIESEKING AND H. J. SNIDER. *Ind. Eng. Chem., Anal. Ed.*, **9** [5] 232–33 (1937).—In order to avoid the difficulties involved in completely decomposing highly aluminous minerals by the J. Lawrence Smith fusion, a more desirable flux was sought which would have a low melting point, would be reactive with silicates at the melting point, and which would not leave a residue of salts difficult to separate from potassium. A mixture of two parts of sodium carbonate and one part of lithium carbonate was found to have these characteristics if potassium is determined by the cobaltinitrite method. This flux appears to be very similar to the composition of a eutectic compound of sodium and lithium carbonates. It melts between 470° and 480°C and is very effective in decomposing soil silicates at temperatures between 500° and 600°C. Sodium and lithium salts do not interfere with the determination of potassium by the cobaltinitrite method. F.G.H.

Excessive accuracy in chemical analysis. G. W. LEEPER. *Jour. Australian Chem. Inst.*, **4** [7] 249 (1937).—A plea is made for common sense in suiting the method of analysis to the material investigated and the purpose for which it is analyzed. H.H.S.

Handling and weighing absorption tubes in microdeterminations of carbon and hydrogen. DOUGLASS F. HAYMAN. *Ind. Eng. Chem., Anal. Ed.*, **8** [5] 342–43 (1936). F.G.H.

Hydrothermal reaction of alkali solutions to kaolins: I. SHOICHIRO NAGAI. *Jour. Japan. Ceram. Assn.*, **44** [524] 531–41 (1936).—Three kaolinite samples from Korea and one sample of Zettlitz kaolin were analyzed, and the results obtained are given in a table. The Zettlitz kaolin was first calcined at various temperatures for several hours, and the insoluble and soluble parts of the calcined kaolin or metakaolin were analyzed by treating with 10% NaOH and 5% HCl solutions. The molecular ratios of (*a*) calcined loss or the amount of water set free by the calcination and (*b*) dissolved alumina in HCl solution to dissolved silica in NaOH solution and the specific gravities were determined in order to discuss the ordinary thermal decomposition of kaolinite and the soluble parts of calcined products. These results show that the calcination at 850° to 900°C is most effective in dissolving the largest amounts of silica and alumina and in making the smallest amount of insoluble residue. Some samples of these calcined kaolins were treated with 30% NaOH solution in an autoclave under the pressure (20 kg./cm.²) of saturated steam vapor (about 210°C) for 1 hr. By filtering the reacted solution, the product insoluble in the alkali solution was obtained in the amount of about 120 to 130%. This amount is larger than the originally used calcined kaolin, showing that the calcined kaolin or metakaolin ($Al_2O_3 \cdot 2SiO_2$) absorbs water to make the original kaolin, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$, or absorbs alkali or both alkali and water to make alkali aluminosilicate or its hydrate, $Na_2O \cdot Al_2O_3 \cdot 2SiO_2$ or $Na_2O \cdot Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$, etc. This product was seen to be easily soluble in dilute alkali and acid and composed principally of Na_2O, Al_2O_3, SiO_2, and H_2O, having the rational formula of alkali alumino-hydro-silicate, $Na_2O \cdot Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$, as presumed above. The results of analyses of the products and the calculated rational formulas are shown. The following points are discussed: (1) calcined kaolin produces the same product, alkali alumino-hydro-silicate ($R_2O \cdot Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$), as that from the raw kaolin; (2) this product from NaOH solution has a larger amount of combined water than that from KOH solution. For comparison with these results, the mixture of pure chemicals of alumina and silica in the molecular ratio of kaolin 1:2 (Al_2O_3:$2SiO_2$) was treated with alkali solution under pressure under the same conditions as above adopted, but the same feldspathic product could not be obtained. Alumina and silica in the calcined kaolin are not in quite as free a state as in the mixture but are in the special combination of a convenient state for the formation of alkali alumino-hydro-silicate by hydrothermal reaction with alkali solution under pressure.

Investigation of slags as a basis for the study of petrological problems: I, Development and methodology. LEO KOCH. *Fortschr. Mineral., Krist., & Petrog.*, **20**, 196–238 (1936).—This is for the greater part a historical survey and contains practically no definite data, except where Levinson-Lessing is quoted and a few figures on Cl and alkali content. K. claims to have looked through 300 references, and there are several pages of references at the end of the article. Two investigators hold a high place in the article: Vogt (especially his "Magmatic differentiation of igneous rocks," 1922–23) and Levinson-Lessing ("Considerations about magmatic and nonmagmatic silicate systems," *Mineralog. Petrog. Mitt.*, **43**, 45 (1932)). K. regrets that the more accurate modern analyses omit smaller impurities such as TiO_2 or K_2O. Mansfelder copper slag, in which he finds great uniformity, and refuse slag, mostly of the city of Cologne, which K. considers very important for his investigation, are especially mentioned. He also refers to special slag formed by penetration of the blast-furnace lining. E.St.

Lead oxide. CARSTEN-HOLTERMANN AND P. LAFFITTE. *Compt. Rend.*, **204** [24] 1813–15 (1937).—Under a pressure of 200 atm., three distinct oxides were found of the form PbO_2, Pb_7O_{11}, and Pb_3O_4 in the temperature range of 360° to 470°C. The experiments are described in detail. Six references. M.H.

Light calcium carbonate. V. CHARRIN. *Verre & Silicates Ind.*, **8** [13] 152 (1937).—V. describes the calcium carbonate used in the manufacture of ceramic materials, paints, paper, rubber, etc., in place of the expensive precipitated carbonate. The carbonate from Orgon (mouth of the Rhône) had the following composition: $CaCO_3$ 97.20 and $MgCO_3$ 2.60. A fine-texture carbonate purified by levigation had a density of 0.4 to 0.5 and the following composition: $CaCO_3$ 98.90%, SiO_2 0.45, Al_2O_3 0.15, Fe_2O_3 0.15, $MgCO_3$ 0.30, and sulfuric acid of sulfates 0.05. M.V.C.

Magnesia–alumina–silica system as dielectric materials. SHIZUTA MORIYASU. *Researches Electrotech. Lab.* [Tokyo],

No. 401, 113 pp. (1936); *Chem. Abs.*, **31**, 3653 (1937).—The equilibrium diagram of the Al_2O_3–SiO_2 system and the deformation temperature of Seger and Orton cones showed that the deformation of the body took place in the presence of 70% liquid. The temperature of the MgO–Al_2O_3–SiO_2 system to contain 70% liquid was calculated and the range of vitrifiable composition determined from equilibrium diagrams. Many samples in the MgO–Al_2O_3–SiO_2 system were made and the dielectric constant, dielectric loss at 10^3 and 10^7 cycles, and the d.-c. resistance at 15 to 19° were determined. The lowest temperature to give a ceramic body was found in the bodies containing 45 to 60% SiO_2 and 10 to 20% Al_2O_3. In pure talc-Katō kaolin system, the resistivity at 400° was expressed by the equation, $\log \rho\,(400°) = -0.029k + 4$, where ρ is resistivity in MΩ and k is the percentage of kaolin in the fired bodies. Electrical resistance of the systems Al_2O_3–SiO_2–alkalis and MgO–Al_2O_3–SiO_2–alkalis was greatly lowered by the presence of alkalis. The low resistivity of kaolin in comparison with talc is due to the presence of alkalis, and the conductance of ceramic bodies greater than $10^{-9}\Omega^{-1}/cm.^{-1}$ at 400° is mainly due to alkali components. Tests on K feldspar indicated that the conductance of a ceramic body greater than the above rate is due to alkalis in the glass phase. It is assumed that alkalis dissociate into ions in glass above the viscous state. Below this temperature the motion of molecules and ions is arrested and the concentration of ions is constant. The heat of dissociation of conducting compounds in glass was calculated to be 13,450 cal./mol. The effect of the other components in the MgO–SiO_2–Al_2O_3–alkalis system on resistivity is discussed.

Manganese problem in the analysis of silicates. Oskar Hackl. *Z. Anal. Chem.*, **105**, 182–99 (1936); *Chem. Abs.*, **30**, 6305 (1936); for abstract see *Ceram. Abs.*, **16** [6] 189 (1937).

Microdetermination of carbon and hydrogen in compounds containing arsenic, antimony, tin, bismuth, and phosphorus. F. C. Gilbert and W. R. Kirner. *Ind. Eng. Chem., Anal. Ed.*, **8** [5] 353–55 (1936).—By a modification of the Falkov-Raiziss macromethod, the microdetermination of carbon and hydrogen in the above compounds can be successfully performed. Illustrated.

F.G.H.

Modification of colorimetric determination of silicic acid in the presence of iron, phosphorus, and fluorine. I. P. Alimarina and V. S. Zverev. *Mikrochemie*, **22** [1] 89-101 (1937) (in English).—The authors present a description of the new modification of Dienert and Wandenbulcke's method for eliminating the influence of interfering elements (iron, phosphorus, and fluorine) in the determination of silicic acid. L.E.T.

Optical spectroscopic determination of boron. Polarizing attachments. R. K. Calfee and J. S. McHargue. *Ind. Eng. Chem., Anal. Ed.*, **9** [6] 288–90 (1937).—Polarizing attachments and an oxygen-methane blast burner for the spectroscopic determination of boron are described. Natural gas saturated with methyl borate in methyl alcohol is ignited in an oxygen blast to excite the spectrum. A standard solution on ignition and polarization produces a reference spectrum in juxtaposition to the spectrum of the sample. The degrees of rotation of the analyzing plate are read on a scale in terms of parts per million of boron in the solution upon matching the intensities of the spectra. Recommendations are given for the treatment of samples containing halides and large amounts of sodium salts. Samples containing from 1 to 600 p.p.m. of boron have been analyzed. Illustrated. F.G.H.

Peroxide method for vanadium, a spectrophotometric study. E. R. Wright and M. G. Mellon. *Ind. Eng. Chem., Anal. Ed.*, **9** [8] 375–76 (1937).—The application of the spectrophotometer to a study of the peroxide method for vanadium is described in detail. Illustrated.

F.G.H.

Phase equilibrium relationships in the binary system sodium oxide-boric oxide, with some measurements of the optical properties of the glasses. G. W. Morey and H. E. Merwin. *Jour. Amer. Chem. Soc.*, **58** [11] 2248–54 (1936).—A study of the phase equilibrium relationships in the system Na_2O–B_2O_3 has shown the existence of the following compounds: sodium orthoborate, $2Na_2O{\cdot}B_2O_3$, with a congruent melting point at 625°; sodium metaborate, $Na_2O{\cdot}B_2O_3$, with a congruent melting point at 966°; sodium diborate, $Na_2O{\cdot}2B_2O_3$, with a congruent melting point at 742°; sodium triborate, $Na_2O{\cdot}3B_2O_3$, with an incongruent melting point at 766°, 76 wt. % B_2O_3; and sodium tetraborate, $Na_2O{\cdot}4B_2O_3$, with a congruent melting point at 816°C. The orthoborate, which is a newly discovered compound, can be cooled to a glass, as can mixtures containing more boric oxide than the diborate. The metaborate and compositions near it crystallize too readily to be quenched to a glass. In addition to the forms stable at the liquidus, sodium diborate may occur in two, and the tetraborate in one, additional forms which are probably monotropic. Attempts to prepare crystalline boric oxide were not successful, and doubt is expressed as to previous claims to its crystallization. Refractive dispersions were measured for boric oxide, sodium tetraborate, and sodium diborate glasses. Illustrated.

F.G.H.

Phosphotungstate method for vanadium, spectrophotometric study. E. R. Wright and M. G. Mellon. *Ind. Eng. Chem., Anal. Ed.*, **9** [6] 251–54 (1937).—A spectrophotometric study of the phosphotungstate method for vanadium was made for the purpose of ascertaining optimum concentration of reagents, effect of acid and diverse ion concentrations, and stability. Typical transmittancy curves are given covering the most useful range of concentration. Procedures are proposed for application of the method to the determination of vanadium in alloy steels. Illustrated. F.G.H.

Potentiometric estimations of copper with sodium sulfide. C. Prasad and J. B. Jha. *Jour. Indian Chem. Soc.*, **12**, 1–3 (1935).—The estimation of copper as $CuSO_4$ is best carried out in sodium acetate-acetic acid buffer solutions of p_H 3 to 5. The potentials at the end-point were found to rise with p_H. A.P.S.

Pressure viscometry of kaolin suspensions. G. Fuks. *Acta Physicochim. U.R.S.S.*, **3**, 137–46 (1935); *Chem. Abs.*, **30**, 4741 (1936).—Viscosity (η) increases rapidly with concentration. The η of sols reaches a maximum after aging and then falls off. The maxima for the 5.32 and 10.43% sols come after five days and four days, respectively, while for a 14.72% solution η falls off from the be-

ginning. Mechanical working increases aggregation. The greater the dispersion the more rapid the structure formation. Dilution causes coagulation. Dehydrating agents hasten the formation of structures.

Production of aluminum oxide and alkalis from nephelite by the alkaline method. N. I. Bogolepov, N. I. Vlodavetz, I. S. Lileev, V. A. Mazel, Ya. M. Pesin, F. N. Strokov, and V. E. Tishchenko. *Trudy Gosudarst. Inst. Priklad. Khim.*, No. 29, pp. 5–266 (in English 267–70) (1936); *Chem. Abs.*, **30**, 5001 (1936).—A detailed discussion of experimental studies during 1930–1935 of the production of pure Al_2O_3 and Na_2CO_3 and K_2CO_3 from Khibinsk nephelite (urtite) and nephelite concentrates, obtained from the nephelite tailings from the enrichment of apatite by flotation of apatito-nephelite, is given. The optimum conditions, with 80% extraction of Al_2O_3 and alkalis, are as follows: dry nephelite and limestone, ground to 175-mesh, are mixed in the proportion of 2 mol. of CaO to 1 mol. of SiO_2 in nephelite (and limestone). The mixture is fired in a rotary kiln at 1180° to 1220° (urtite) or 1240° to 1280° (nephelite concentrate) for 1.5 to 2 hr. The melt, ground to 80-mesh, is lixiviated with 0.5 mol. of Na_2CO_3 to 1 mol. of Al_2O_3 (or with the mother liquor of the carbonation of the aluminate solution), giving an aluminate solution containing $Al_2O_3 \sim 100$ g./liter. The aluminate solution is freed from SiO_2 and P_2O_5 by autoclaving with 1% CaO at 5 to 7 atmospheres for 2 hr. and filtering from the white sludge. The filtrate is treated with CO_2 at 80° to 90°; the $Al(OH)_3$ is filtered off and calcined to Al_2O_3. No waste products result by this process, because all the component parts of nephelite and limestone are utilized. Na_2CO_3 and K_2CO_3 in the filtrate are either separated by isothermic evaporation or mixed with apatite concentrates and reworked into thermophosphates. SiO_2 and other components of nephelite and CaO in the sludge from the lixiviation of the melt are converted into nephelite cement equal in quality to Portland cement. See "Volumetric—," *Ceram. Abs.*, **14** [1] 24 (1935).

Qualitative gravimetric analysis through direct precipitation in Jena glass filter crucibles. G. G. Longinescu and I. I. Prundranu. *Bull. Sect. Sci. Acad. Roumaine*, **18** [6–7] 7 pp. (1936); abstracted in *Chem. Zentr.*, **1937**, **i**, 4996–97.—The analysis is discussed with examples from the determinations of Cu as CuS, Cl′ and Br′ as Ag-halogenides, and Ba as $BaSO_4$. M.V.C.

Quantitative analysis of mine dusts. X-ray diffraction method. George L. Clark and Dexter H. Reynolds. *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 36–40 (1936).—An empirical method for the quantitative analysis of mine dusts in terms of their mineralogical content using X-ray diffraction is described. A crystalline compound which is not present in the dust sample is added to it in a definite ratio. The densities of a diffraction line of the constituent sought and of a line of the added substance are compared photometrically. From the ratio the amount of the substance sought may be determined by reference to a curve in which similar ratios are plotted against per cent substance sought, the curve being prepared using synthetic standard samples of known composition. Duplicability of results is within 5% of the amount of the substance sought in the case of quartz. The method has been applied only to quartz-silicate ore mixtures ranging between 0 and 100% but should prove applicable to many other minerals. Illustrated. F.G.H.

Quantitative determination of aluminum by precipitation with urea. Hobart H. Willard and Ning Kang Tang. *Ind. Eng. Chem., Anal. Ed.*, **9** [8] 357–63 (1937).—Aluminum can be accurately separated from large amounts of calcium, barium, magnesium, manganese, cobalt, nickel, zinc, iron, cadmium, and copper by precipitation as the dense basic succinate by boiling with urea the acid solution containing succinic acid. Hydrolysis of the urea forms ammonia gradually in a homogeneous solution, resulting in a p_H of 4.2 to 4.6. Owing to the dense nature of the precipitate, it is easily filtered and washed and shows much less adsorption of other salts than does the precipitate obtained by the usual methods. The basic sulfate precipitated in this way is also dense, but the p_H must be 6.5 to 7.5 and separations in certain cases are less satisfactory. The accuracy of separations made by the urea method is far superior to that obtainable by the use of ammonia. This is attributed to a combination of the following four important factors: a dense precipitate, a slow, uniform increase in p_H, a homogeneous solution, and a low final p_H. F.G.H.

Rapid analysis of barite ores containing calcium fluoride, without use of fusions. Ellis S. Hertzog. *Ind. Eng. Chem., Anal. Ed.*, **9** [7] 336–38 (1937).—This method is intended to give the amount of calcium carbonate, barium sulfate, and calcium fluoride present in barite ores which contain a considerable amount of calcium fluoride. All calcium compounds other than calcium fluoride are first leached from the sample and reported as calcium carbonate. Then the calcium fluoride, together with other acid-soluble compounds, is decomposed by a new wet method, leaving the barium sulfate and a small amount of silica behind as a residue. The amount of calcium oxide obtained from the decomposition of the calcium fluoride is then determined, and from this the fluorine or calcium fluoride is calculated. F.G.H.

Rapid determination of total alkalis in ceramic materials. V. Majer. *Zprávy Československ. Keram. Společnosti*, **11**, 13–23 (1934); *Chem. Zentr.*, **1935**, **ii**, 3146; *Brit. Chem. Abs.-B*, **56**, 549 (June, 1937).—The material (5 to 20 mg.) is moistened in a Pt crucible with 0.3 cc. of N/H_2SO_4 and evaporated with 0.5 to 1 cc. of 40% HF; 1 to 2 drops of N/H_3PO_4 and 1 cc. of 0.5 to 1 N/NMe_4·OH are added to the residue, when Al goes into solution and Mg, Ca, Ti, and Fe form insoluble compounds; 0.5 to 1 cc. of H_2O is added and the polarigraphic electrolysis is carried out. See "Polarigraphic—," *Ceram. Abs.*, **12** [8] 312 (1933).

Rapid method for the determination of titanium. Henry B. Hope, Raymond F. Moran, and Arthur O. Ploetz. *Ind. Eng. Chem., Anal. Ed.*, **8** [1] 48–49 (1936).—The method consists in the reduction of the titanium to the trivalent state by use of liquid zinc amalgam and its titration with ferric ammonium sulfate using potassium thiocyanate as an indicator. The end-point is the appearance of the usual wine-colored ferric thiocyanate complex. Illustrated. F.G.H.

Rare earth metals and their compounds. Thermal analysis of rare earth nitrate mixtures. Laurence L. Quill, Richard F. Robey, and Sam Seifter. *Ind. Eng. Chem., Anal. Ed.*, **9** [8] 389–92 (1937).—A method of

analysis is proposed which utilizes the characteristic melting points of the hydrated salts and the liquidus curves of the binary salt mixtures for the estimation of the composition of rare earth mixtures. Several binary salt systems were investigated, employing very pure simple and double rare earth nitrates to provide basic information concerning the possibilities of the method. Illustrated.

F.G.H.

Reduction of selenium dioxide by carbon monoxide. EDWARD BARNES. *Jour. Indian Chem. Soc.*, **12**, 22 (1935). —By subliming continually a quantity of selenium dioxide from one side of a vessel to the other in a stream of CO, slow reduction occurs by strong heating with a bare gas flame. Ultra-violet light at room temperature has no effect.

A.P.S.

Relation of the calcium and hydrogen ions to some physicochemical properties of clays. J. F. LUTZ. *Amer. Soil Survey Assn., Rept. 16th Ann. Meeting, Bull.*, No. 17, pp. 24–27 (1936); *Chem. Abs.*, **30**, 5339 (1936).—H-saturated and Ca-saturated colloids of the *B* horizon of Putman (I), Iredell (II), and Davidson (III) soils were compared. The III colloids flocculated rapidly and II less rapidly; I colloids were stable for several days. The Ca and H suspensions were equally stable in I and III, and the Ca was more stable than the H suspension in II. Viscosity measurements indicated that the H colloids were more highly hydrated than the Ca colloids, probably because of occluded H_2O. Membranes of H clay were more permeable to water than those of Ca clay because of lower zeta potential.

Sensitiveness of magnesium uranyl acetate reagent to sodium and potassium. CHARLES H. GREENE. *Ind. Eng. Chem., Anal. Ed.*, **8** [5] 399–400 (1936).—G. presents data showing how the sensitivity of magnesium uranyl acetate reagent toward sodium and potassium varies with the proportion of the reagent used in the test and with the presence of alcohol. Illustrated.

F.G.H.

Separation of beryllium in the presence of complex tartrates. HOKE S. MILLER. *Ind. Eng. Chem., Anal. Ed.*, **9** [5] 221 (1937).—M. has found that beryllium may be precipitated from its complex tartrate solution by means of an optimum hydroxyl-ion concentration provided by the addition of ammonium hydroxide. In this way it is possible to separate beryllium, to a fairly quantitative extent, from such elements as aluminum, iron, copper, and chromium; these form complex tartrates from which the hydroxides of the metals are not precipitable upon addition of an optimum quantity of ammonium hydroxide.

F.G.H.

Studies of the constituents of refractory clays by means of thermal analysis. A. JOURDAIN. *Céramique*, **40** [593] 135–41 (1937).—Kaolinite becomes noticeable with the volatilization of water at 500° to 550° and by a marked exothermic bend between 900° and 1000°, indicating a crystallization probably into a mixture of mullite and tridymite. Halloysite shows the same characteristics but loses its hygroscopic water at 120°. Montmorillonite (clay closely related to bentonite) is used as bond for refractories and as decolorating or activating clay. Thermal curves of this clay are characterized by the following endothermic bends: (1) at 125° to 150° which corresponds to a loss of water of absorption, and (2) and (3) at 600° to 675° and 800° to 850°. Small differences may exist among various samples of this group of clays because of the physical state and the distribution of crystalline lamellas; nacrite and dickite are kaolinites with a slightly different crystalline structure. Hydrargillite is characterized only by a large loss of water at 300° to 350°. Allophane has an important endothermic bend at 150° which does not correspond to the loss of hygroscopic water by moist clays. Pyrophyllite yields very uncertain and variable results. Beidellite produces 2 endothermic bends, *i.e.*, loss of water of absorption at 120° and another at 550° to 600°. All these clays are refractory. These experiments must be completed by a severe chemical analysis to determine chemical formulas of the products because of the fact that the determination of the different kinds of water, such as water of absorption, water of constitution, and zeolitic water, is of great importance. Water of absorption or hygroscopic water is retained physically only by adherence and its loss does not modify the crystalline structure. The loss of water of constitution modifies the crystalline structure, and in this case, fired clay becomes unable to recover the hydroxides. It is chiefly the loss in water of constitution which permits the differentiation among the various mineralogical types of clays. Zeolitic water constitutes a part of the crystalline structure where it fills the symmetrical voids between the atoms, and its loss modifies slightly the crystalline structure.

M.V.C.

Swelling of sand. A. S. VASILIEV. *Kolloid Zhur.*, **1** [2] 51–59 (1935); *Brit. Chem. Abs.-B*, **56**, 344 (April, 1937).—Quartz sand, treated with concentrated HCl and washed, quickly absorbs $Ca(OH)_2$ and sets. Subsequently the formation of $CaSiO_3$ takes place slowly.

Symmetrical extinction angles of albite-twinned plagioclases. SEITARO TSUBOI. *Proc. Imp. Acad.* [Tokyo], **11**, 423–25 (1935); *Chem. Abs.*, **30**, 6258 (1936).—A new diagram which corrects the classical one of Wright giving the range of symmetrical extinction angles of X'A trace of (010) in albite twinned plagioclases is presented.

Technical aspects of silicate of soda manufacture. E. ELIOVSON. *Jour. S. African Chem. Inst.*, **20** [1] 12–16 (1937); *Chem. Abs.*, **31**, 3216 (1937).—The design and operation of a pilot plant and of a semicommercial furnace for making Na silicate by fusing Na_2CO_3 and pure quartz sand are described. A vertical, stationary digestor was used for dissolving the fusion in H_2O. Solutions of 44° to 48°Bé were produced and suspended matter was removed by diluting, filtering, and concentrating again. The solution must not be placed in galvanized drums, because H is liberated. The methods of analytical control and the uses of the product are discussed.

Thermal decomposition of barium carbonates. L. HACKSPILL AND GEORGE WOLF. *Compt. Rend.*, **204** [24] 1820–22 (1937).—The results of a systematic study of the decomposition $CO_3Ba \rightleftharpoons CO_2 + BaO$ are reported.

M.H.

Thermal decomposition of the mullitic phase. V. ŠKOLA. *Sklarske Rozhledy*, **13**, 52–56, 71–74 (1936); *Chimie & Industrie*, **37**, 101 (1937); *Chem. Abs.*, **31**, 3654 (1937).—In the presence of alkali, mullite brick decompose as low as 1400°, contrary to the indications of Bowen and Greig (*Jour. Amer. Ceram. Soc.*, **7** [4] 238–54; [5] 410 (1924)). In the absence of alkali, however, mullite shows

considerable stability even above 1500°; 1% alkali is sufficient to produce considerable decomposition. The presence of SiO_2 affects the decomposition phenomenon even in the presence of alkali. The tests indicate that in commercial furnaces, and especially in glassmelting furnaces, a corundum base material is preferable to mullite brick. See *Ceram. Abs.*, **16** [10] 304 (1937).

Thermal dissociation of ferric oxide. FRANCIS MEUNIER AND OSCAR L. BIHET. *Congr. Chim. Ind., 15th Congress, Brussels, Sept., 1935*, 944–51 (1936); *Chem. Abs.*, **30**, 5490 (1936).—The law of dissociation of the system Fe_2O_3–Fe_3O_4–O_2 (O_2 pressure as a function of temperature) was determined by a very accurate dynamic method. The analytical expression was calculated according to Nernst's law, which revealed by means of the phase rule the partial miscibility of the two oxides in the solid state; this was confirmed by the X-ray analysis.

Total analysis of chromite ore and chromite-containing ceramic materials. WOLFRAM ERBER. *Angew. Chem.*, **50**, 382–83 (1937); *Chem. Abs.*, **31**, 5965 (1937).—The acid and alkaline methods are discussed. The new method is based on the use of $NaHSO_4$ for breaking down the sample. The $NaHSO_4$ (about 5 g.) is dehydrated in a Pt crucible, about 0.5 g. of sample is added, and the mixture is heated to redness, and cooled with constant swirling until solidified. The melt is dissolved in H_2O and the filtrate collected in a 500-cc. volumetric flask and filled to the mark. Aliquot parts are used for the determination of Cr + Fe, and for Fe + Al + Cr. Ca and Mg are determined in the usual manner. The determination of Fe can be combined with that of Cr by dissolving the precipitate obtained from the alkaline oxidation of Cr (with $KMnO_4$) in HCl and titration according to Reinhardt. Nineteen references.

Two-dimensional crystals of Si_2O_3. N. A. SHISHAKOV. *Nature*, **139** [3526] 927 (1937).—S. deduces two-dimensional crystallinity for the silicon oxide in clay and pozzolanas from the electron diffraction patterns of these materials and their similarity to the rings shown in the diffraction patterns of vitreous silica and pumice. The silica shows all of the rings of the clays but the clays do not contain some of the silica rings. S. presents a table showing the Bragg spacings of the clays. From these values he states that the third index is zero and the lattice two-dimensional. Therefore the bonds between the SiO_4 tetrahedra are of the same type as in mica and the crystals have the form of endless firm sheets of the composition Si_2O_3. J.L.G.

Ultra-centrifuge and the study of high-molecular compounds. THE SVEDBURGH. *Nature*, **139** [3529] 1051–62 (1937).—S. discusses the ultra-centrifuge as applied to the molecular weight analysis of high-molecular compounds, particularly the proteins. 47 references. J.L.G.

Use of waste glass in the manufacture of sodium silicate. R. L. DATTA AND R. N. MOOKERJEE. *Dept. Ind. Govt. of Bengal, India, Bull.*, No. 70; *Chem. Abs.*, **31**, 3216 (1937).—Experiments are described for the production of cheap Na silicate of low SiO_2 ratio, suitable for use in the soap industry, with waste glass of the soft type, with a view to replacing the silicate now made from imported Na_2CO_3.

Viscosity of the system $K_2B_4O_7$–B_2O_3 in the fused state. M. P. VOLAROVICH AND R. FRIDMAN. *Acta Physicochimica U.R.S.S.*, **6**, 393–400 (1937); *Jour. Soc. Glass Tech.*, **21** [85] A206 (1937).—The viscosities are determined by Margule's method, the material being contained between two coaxial platinum cylinders. For boric oxide the temperature viscosity relationship is given within 1 to 2% by the equation

$$\log \frac{\eta}{2.114} = \frac{1450}{t - 150.8}.$$

The viscosity isotherms for the complete system, relating viscosity to composition, give maxima from 620° to 1000° in the neighborhood of the $K_2O3B_2O_3$ composition, being more pronounced the lower the temperature. No second maxima corresponding to $K_2O4B_2O_3$ can be detected, for this composition readily devitrifies, a condition which it is thought might indicate the existence of this compound also in the molten state. This type of relationship between viscosity and composition is exactly similar to that obtained by M. P. Volarovich and D. M. Tolstoi.

Volumetric estimation of chlorides and sulfates in a mixture containing both with the help of an adsorption indicator. M. B. RANE AND K. R. APTE. *Jour. Indian Chem. Soc.*, **12**, 204–207 (1935).—$CdSO_4$ has been titrated directly with $Ba(OH)_2$, using fluorescein as an adsorption indicator. Cl' and SO_4'' in a mixture are successively determined in the same solution by Ag acetate followed by barytes, with fluorescein serving as an adsorption indicator for both. A.P.S.

BOOKS

New Practical Chemistry. N. H. BLACK AND J. B. CONANT. Macmillan & Co., New York, 1937. Price $2.00. Reviewed in *Discovery*, **18** [208] 130 (1937). H.H.S.

Silicate Analysis. A. W. GROVES. Thomas Murby & Co., London, 1936. xxii + 230 pp., 11 figs. Price 12s 6d. Reviewed in *Jour. Soc. Glass Tech.*, **21** [85] A230 (1937).—This book, in which G. has kept constantly to the fore the needs of the petrologist as well as the analyst, is of convenient size for use in a laboratory, and, for the greater convenience of the worker, the instructions are printed in larger type than the general outlines of the procedures. The first part is concerned with descriptions of (1) laboratory equipment, alternatives being suggested in cases where the usual services of gas, power, etc., are not available; (2) chemical reagents; (3) sampling and preparation of materials to be analyzed; (4) constituents generally to be determined in rock analysis; and (5) common operations, including weighing, filtering, washing, and ignition of precipitates and the care of platinum vessels.

Then follows a long chapter (VI) dealing with the normal methods of analysis applicable to rocks, the scheme being clearly outlined diagrammatically at the outset. In this section it is a pity that a wide and general statement is made which would be misleading in glass analysis. This generalization (p. 82) reads, "Ferrous oxide is the simplest and quickest determination in silicate analysis," but in the case of many glasses this determination has been found to call for very careful control of conditions if reliable and reproducible results are to be obtained. G. no doubt had in mind rocks, for later, when discussing the permissible limits of error to be allowed in first-class rock analysis, the values ±0.02 and ±0.03 for ferrous oxide (FeO) and ferric oxide (Fe_2O_3), respectively, were given, expressed as percentages of the sample. Such limits could not apply to

glasses where the total iron content may be of the order of 0.05% Fe_2O_3, or even lower, with ferrous oxide possibly not above 0.01%.

Thirteen pages are devoted to "special methods" (*a*) for some constituents under special conditions and (*b*) when the amount of material available is very small. In the short chapters which follow, dealing with technological applications and special cases, are included glassmaking sands, clays, refractories, coal ash, and mineral residues from human silicotic lungs.

Interesting and useful short chapters are devoted to the discussion of sources and limits of errors and qualitative tests to decide whether certain constituents are worthy of determination; then a longer section deals with the geochemical distribution of the elements. The work concludes with a chapter on computations as checks on the accuracy of the chemical analysis of rocks and minerals and three appendices giving (*a*) conversion factors, (*b*) a specimen calculation of rock analysis, and (*c*) the statement of the analysis. A subject index is provided.

The book is handy, printed clearly, moderately priced, and should be very useful to those dealing with rocks and minerals. In spite of its title, implying a very wide application, it can not, however, for the glass and enamel analyst, replace the older works such as Quantitative Inorganic Analysis, by J. W. Mellor, and Applied Inorganic Analysis, by W. F. Hillebrand and G. E. F. Lundell; *e.g.*, when treating of boron, which is commonly found in glasses today, low iron contents such as are met in glassmaking sands, and a full analysis of limestone, the reader is referred to the older works. Other constituents often met in glasses and enamels, such as lead, cadmium, antimony, and selenium, do not appear to have been included. On the other hand, the book contains interesting modifications of some methods given in the older books and some new methods. Determinations for which modifications are given include those of fluorine, nickel, copper, and strontium. G. is to be congratulated on having condensed into this volume so much of real value, which should help, as he hopes, to accelerate the output of geochemical data of a high standard of accuracy.

ERRATUM

Rapid method of determining silica with the aid of oxyquinoline in quartzites, silica and grog materials, and clays. M. I. Volynetz and S. S. Bernsteyn. *Ceram. Abs.*, **16** [7] 223 (1937). The journal reference should read as follows: *Zavodskaya Lab.*, **5** [9] 1071–72 (1936).

PATENTS

Glass, glazes, and enamels. Deutsche Tafelglas A.-G. (Detag). Fr. 797,295, April 23, 1936; *Chem. Abs.*, **30**, 6522 (1936). The stability of these toward chemical agents is improved by the introduction, while in the fused state, of steam or materials liberating steam, in a proportion, *e.g.*, of 0.35% or concentration determined by the degree of improvement desired.

Glass, glazes, and enamels and method of making. Rudolf Geppert and Adolf Dietzel (Deutsche Tafelglas A.-G.). U. S. 2,093,194, Sept. 14, 1937 (Nov. 1, 1935). In a process for the manufacture of glass, glazes, or enamels of improved chemical resistivity, the steps comprise acting on the glass, glaze, or enamel with water-vapor while they are in the molten state until increased quantities of water are incorporated in the molten mass, and preventing the escape of the incorporated quantities of water.

Recovery of beryllium from siliceous ores. B. R. F. Kjellgren and C. B. Sawyer (Brush Beryllium Co.). U. S. 2,092,621, Sept. 7, 1937 (Dec. 10, 1932; renewed Aug. 25, 1936). The process of treating siliceous beryllium ores comprises mixing carbon and iron with the ore, heating the mixture to form an iron-silicon alloy and a slag containing the beryllium of the ore and less silica than the original ore, separating the iron-silicon alloy from the slag, and treating the slag with mineral acid to decompose constituents of the slag and recover the beryllium.

General

Action of silica as modified by the presence of alkalis. C. P. McCord, H. Ainslee, J. Johnson, and R. L. Fleming. *Indian Med. Record*, **5**, 17–20 (1936); *Chem. Abs.*, **30**, 4585 (1936).—In investigations on employees at six plants, alkali dust did not appear to increase susceptibility to silicosis. The intraperitoneal injection of Na_2CO_3, $NaHCO_3$, $MgCl_2$, or $CaCl_2$ into guinea pigs gave no evidence of acceleration or inhibition of formation of silica nodules. The primary toxicity of SiO_2 and SiO_2 gel is increased by the addition of alkalis. 15 references.

A.S.T.M. Committee on Glass organized. Anon. *Bull. Amer. Ceram. Soc.*, **16** [9] 372 (1937).

Clay products and nonclay refractories. Anon. *Index* [New York Trust Co.], **17** [9] 192–99 (1937).—This is an analysis of statistical data of the Bureau of the Census (U. S. Department of Commerce) and embraces those establishments which are primarily engaged in the production of brick, drain, and other types of tile, sewer pipe, stove lining, terra cotta, and various nonclay refractory materials. During 1935, the value of all such products reached a total of over $100,000,000, which figure is about 1/3 the value of the production in the period 1923 to 1927 in which the clay products and nonclay refractories industry reached the peak of its production on a value basis. The early history and development of the refractory industry are discussed. M.V.C.

Goggles, masks, and protective devices for the head. R. E. Tugman. *Ind. Chemist*, **12** [136] 207–10 (1936).—It is generally recognized that eye injuries are the most serious of all nonfatal industrial accidents. Goggles are required to give protection against dust and flying particles, splashes of acid, alkalis, molten metal, irritant gas, and glare. The "lens" should have strength to resist flying objects, clarity, light weight, resistance to corrosives, and little tendency to dim. At present four classes of material may be used as "lens": plain, laminated, and toughened glass and noninflammable celluloid. Plain glass has such a tendency to fracture that often it constitutes a hazard rather than a protection. Laminated glass offers great protection, a very heavy blow being necessary to cause even small fragments to fly. Toughened glass also offers a high resistance to flying objects, but when broken,

the fragments might cause serious injury to the eye. Non-inflammable celluloid has a very high resistance to flying objects but its clarity and susceptibility to scratching leaves much to be desired. T. discusses the question of protection against dust, gases, and fumes. H.E.S.

Henry LeChatelier: II, His publications. ALEXANDER SILVERMAN. *Ceram. Abs.*, **16** [10] 316–22 (1937); for Part I see *Bull. Amer. Ceram. Soc.*, **16** [4] 155–63 (1937).

Lung capacities of pottery workers suffering from silicosis in various stages of development. TORSTEN BRUCE. *Trans. Ceram. Soc.*, **35** [12] 561–69 (1936).—Discrepancies between X-ray and clinical examinations of men working in steel foundries, flint mills, and potteries in Sweden led to spirometric investigations in which lung volumes were determined with Knipping's spirometer and residual air was estimated by the hydrogen method. No parallelism between the subjective pathological symptoms and the X-ray stage of the disease was found and it is believed that from the viewpoint of practical insurance it is more important to know the lung function, as judged from clinical examinations and determinations of lung volumes, and the capacity for work, as estimated by the determination of the function of the heart, of a person diseased than to know the appearance of the X-ray picture of the lungs. See "Mineral—," *Ceram. Abs.*, **16** [1] 49 (1937).

R.H.H.P., JR.

New process North Carolina kaolin refinery. J. R. GROUT, JR. *Bull. Amer. Ceram. Soc.*, **16** [10] 387–90 (1937).

Patents and ceramics. F. B. FLICK. *Bull. Amer. Ceram. Soc.*, **16** [10] 392–400 (1937).

Principles of the testing of ceramic materials. RUDOLF BARTA. *Brit. Clayworker*, **46** [544] 169–70 (1937).—Only rarely can ceramic materials be selected or judged by one property alone; moreover, some of these properties lack precise significance if determined alone. Test methods must combine a reproduction of those effects to which the material tested will be exposed in use with a maximum of reliability, simplicity, economy, and speed. Comparison of results obtained by different workers is possible only if standard test methods have been used. Ceramic test methods may be classified as follows: (1) physical, (2) chemical, and (3) ceramic tests. B. divides each of these divisions into numerous subdivisions. R.A.H.

Rating the job and the man. J. E. WALTERS. *Factory Management & Maintenance*, **95** [6] S-393–404 (1937).—W. discusses methods which have been used to rate both the work and the man. Facsimiles of rating charts which have been used by several of the larger corporations are shown. J.L.G.

Who began vitrified porcelain sanitary ware making? ANON. *Bull. Amer. Ceram. Soc.*, **16** [9] 384–86 (1937).

PATENTS

Fixing of metal bolts to ceramic articles and method of manufacturing. C. R. COOK. Brit. 470,758, Sept. 1, 1937 (Feb. 17, 1936).

Refining clay and like ceramic materials. ERICH KREISEL. Ger. 628,182, April 1, 1936; Cl. 80*a*. 1.05; *Chem. Abs.*, **30**, 4640 (1936). A vessel which can be sealed from the air is charged with the material up to about three-quarters of its height, and the remaining space is filled with water. The whole is then subjected to considerable pressure for several hours.

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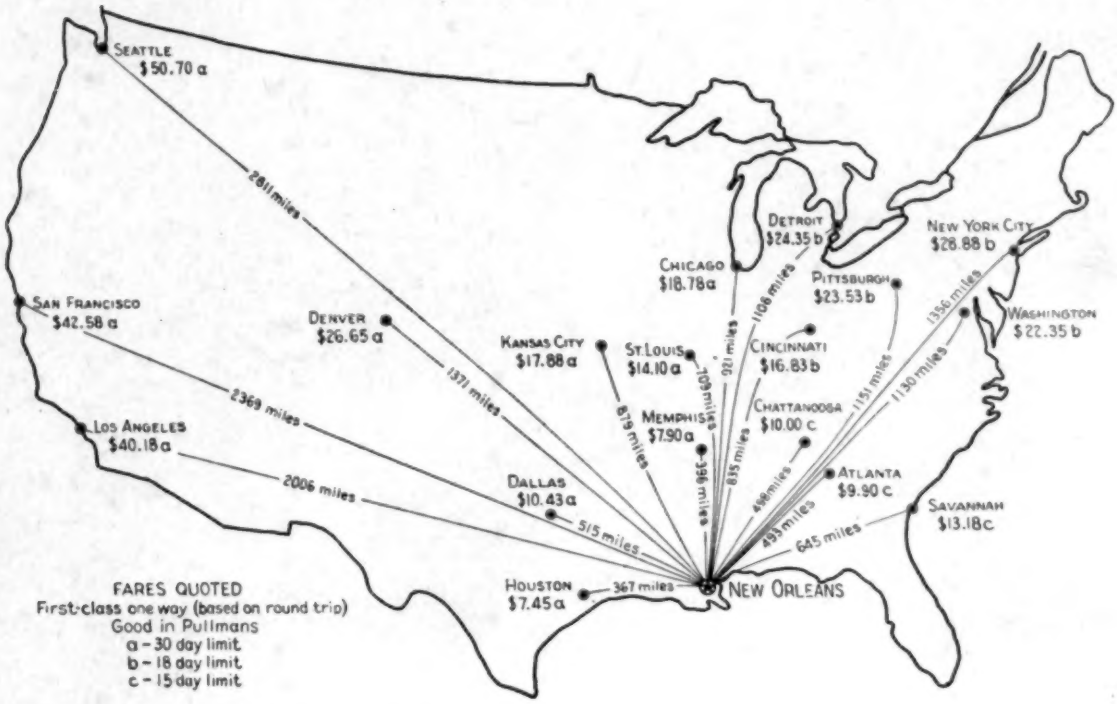

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